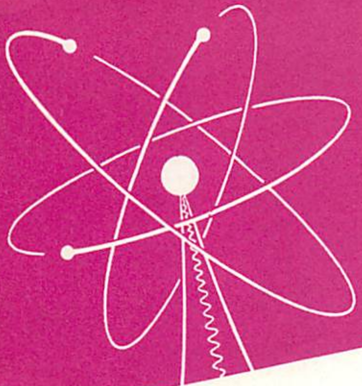

SHADOW MASK TUBE CIRCUITS

Lesson T4E-11A

DeVRY Technical Institute

4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

T4E-11A

SHADOW MASK TUBE CIRCUITS

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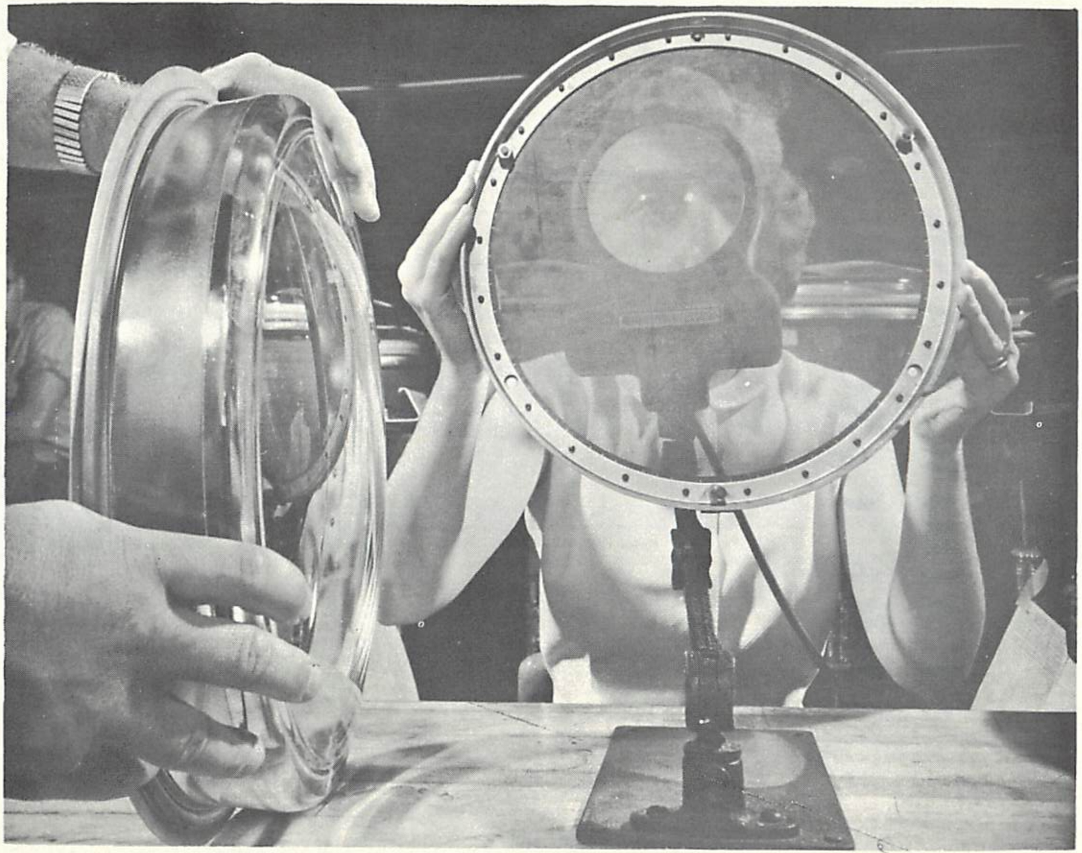

On the left, a face plate and on the right a shadow mask of a color picture tube are being inspected at the factory.

Courtesy RCA Victor

SHADOW MASK TUBE CIRCUITS

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Without arguing the point, let it be assumed that our economic system is capable of supporting a widespread television service, if it proves to be of considerable value to the community. This assumption is undoubtedly in accord with fact.

Television will contribute to our standard of living in at least three ways. First, through its cultural and educational value; second, as a source of entertainment; and finally, as an extension of our senses.

—Selected

SHADOW MASK TUBE CIRCUITS

One of the major contributions toward making color television broadcasting a reality has been the development of the shadow mask tri-color picture tube. Before this tube became available color television was in use, but the reproduction unit was a rotating color filter in front of an ordinary picture tube.

This system is very satisfactory for closed circuit television. Therefore, it is used in those industrial television applications where color is important. However, it does not lend itself to a compatible system. That is, a television broadcast suitable for this rotating filter cannot be received on conventional black and white receivers without considerable modification. In addition the mechanical disc tends to make the receiver too bulky for good home viewer acceptance.

Since the shadow mask tube is so important to color television broadcasting, we must understand those circuits needed to reproduce a color picture on such a tube.

PICTURE TUBE CIRCUITS

Actually every circuit in the receiver cooperates to get the signal to the picture tube. The final signals in the matrix are combined properly to get the original colors of the transmitted scene. Once the signal arrives at the picture tube, the same sequence of the scanning must be applied as at the transmitter. Due to the construction of the picture tube, focus and convergence compensating circuits must be added along with the usual deflection system found in monochrome receivers.

In an effort to reduce costs and make servicing easier, TV manufacturers are constantly seeking to reduce the number of parts. Essentially this is done by reducing the number of receiving tubes used in the set. Associated with each tube are resistors, capacitors, and inductors, which then are not needed. Thus, the total number of parts is reduced even further by eliminating entire stages.

At present, color TV is rapidly progressing along these lines. As a result, a number of manufacturers are changing their receivers. Primarily, the change is taking place in the circuits associated with the picture tube.

RECEIVER MATRIX AND COLOR AMPLIFIERS

It is at this point we take up the signals fed from the demodulators to the matrix where the amplitude and polarity of the E_I', E_Q' and E_Y' signals are properly mixed to recover the original E_R', E_G' and E_B' camera voltages. These latter three voltages are then amplified and applied to their respective guns in the color picture tube which, in turn, reproduces the original scene colors.

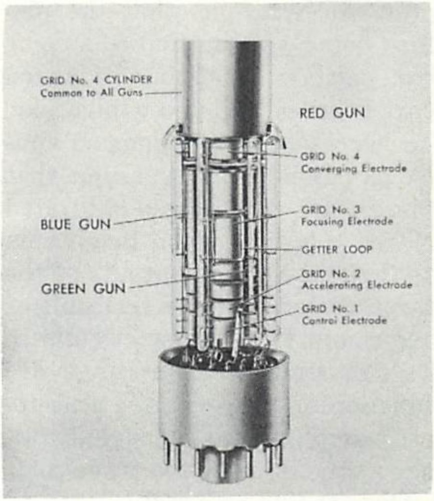
Green Video Amplifier

The block diagram of Figure 1A illustrates the basic requirements of the matrix and the color video amplifiers in a wide-band chrominance receiver. Here, the Y signal is combined with the correct proportions of the I and Q signals to form the E_G' signal at the input to the GREEN ADDER. The combined signal is amplified and appears in the output of the green adder as $-E_G'$. The minus sign merely indicates that the picture phase is negative and requires a polarity reversal before it can be applied to the grid of the green gun in the color CRT.

This reversal of polarity, along with additional amplification is obtained in the GREEN OUTPUT stage. Finally the signal is applied to the grid of the green gun and to the GREEN D-C RESTORER which compensates for the d-c portion of the video signal lost due to the use of coupling capacitors between the various stages.

Blue Video Amplifier

The Y signal is also combined with the proper values of the I and Q signals at the input to the BLUE ADDER where it is amplified and appears as $-E_B'$. The BLUE OUTPUT STAGE provides additional amplification and a polarity reversal so that the picture phase is positive when it is applied to the grid of the blue gun in the color CRT. A BLUE D-C RESTORER is also included at the input to the blue grid.



Three electron guns in a tricolor picture tube.
Courtesy RCA Victor

Red Video Amplifier

The adder and output circuits of the red video amplifier are almost identical to those in the green and blue video amplifiers, the main difference being in the amplitude and polarity of the I and Q signals that are mixed with the Y signal.

Phosphor Efficiencies

Up to this point, nothing has been mentioned about the relative amplitude of E_R', E_B' and E_G' that is necessary to cause proper reproduction of the colors by the three-gun color picture tube. Suppose, for example, that the picture being transmitted is a color bar pattern consisting of a red bar, a green bar and a blue bar. To keep the explanations as simple as possible, let us assume that these bars are 100% saturated NTSC colors of equal brightness so that the voltage outputs of the three cameras at the transmitter are equal. If all other circuits in the transmitter and receiver are functioning properly, the peak-to-peak amplitude of the signal voltage at the input to the three color adders should be equal.

The actual amplitude of these voltages will depend upon the gain capabilities of the following amplifier stages. In this case, let us again assume that the amplitude of the signal voltage at the input to the green adder is three volts peak-to-peak when the green bar is being scanned at the transmitter. Accordingly, the peak-to-peak amplitude at the input to the blue adder is three volts while the blue bar is being scanned and the amplitude of the signal is three volts peak-to-peak at the input to the red adder while the red bar is being scanned.

If the light-emitting qualities of the three phosphors used to construct the dot screen were equal, it would merely be necessary to amplify the three color signals to a point where the three phosphors give off sufficient light. Unfortunately, the efficiency of the red phosphor is considerably less than the efficiency of the blue and green phosphors, making it necessary to amplify the red video signal more than the green and blue signals. As a result the red video amplifier is usually operated at maximum gain while the blue and green video amplifiers have controls to reduce their gain. In this way, we can control the amplitude of the three signals so that the three bars are reproduced with equal brightness on the face of the CRT.

Color Amplifier Circuits

Figure 2 is the schematic diagram of the circuit used for the green adder and the green output amplifier. It is very similar to any ordinary video amplifier with L_1 providing high frequency peaking, and the feedback from the cathode of V_2 to the grid of V_1 providing low-frequency degeneration. The red and blue video amplifiers are the same except that the red amplifier does not contain a gain control.

The color video amplifiers of Figure 3 represent another system which is also employed in wide band receivers. Since there is only one stage of amplification before the signals are applied to their respective grids, the polarities of the Y, I and Q signals must be opposite to that normally used. Therefore, at the input to the red video amplifier we have $-.945E_I'$ $-.621E_Q'$ which is equal to $-(R\text{-}Y)$. To this is added $-E_Y'$ which results in $-E_R'$. The amplifier then changes the signal to E_R' in the plate circuit.

The same situation holds true in the blue and green video amplifiers so that the polarity of the signals in Figure 3 are the opposite to those shown in Figure 1A at the input to the adders.

Narrow Band Color Amplifiers

Figure 1B is the block diagram of the color amplifiers in a narrow band chrominance receiver. Once again, the minus signs preceding the various designations indicate that the signal voltage has a negative picture phase. The output of the R-Y demodulator is a negative signal which, after it is amplified and reversed in polarity by the R-Y amplifier, is applied to the grid of the red gun. A similar condition holds true for the B-Y signal.

In order to obtain the G-Y signal, $-.51$ (R-Y) must be mixed with $-.19$ (B-Y). In Figure 1B we pick off positive values of R-Y and B-Y and apply them to the input of the G-Y amplifier. This is effectively a $-$(G-Y) signal which is amplified and phase inverted before it is applied to the grid of the green gun.

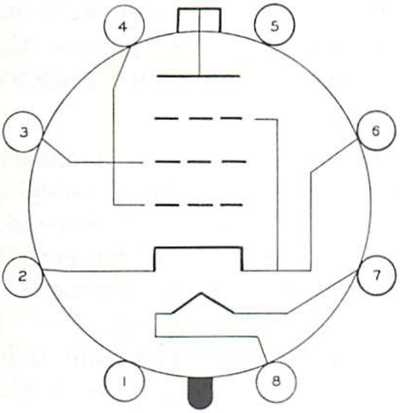
Finally, a negative Y signal is applied to the cathodes of the three guns. This is the same as applying a positive Y signal to the grids because the combined action of this signal and the color-difference signals on the grids has the same effect as applying E_R', E_G' and E_B' to their respective grids.

In some narrow-band chrominance receivers, the Y signal is added to the color-difference signals by means of adder circuits in the same manner as the Y, I and Q signals are combined in Figure 1A. The important point to remember is that the signals must be added together with the proper polarity in order to produce correct colors.

D-C RESTORERS

As explained previously, a d-c restorer is a clamp circuit which re-inserts the direct current component of the signal lost through coupling devices. Signals were directly and capacitively coupled into the matrix, and from the output of the adders, the signals again are resistance-capacitance coupled. Hence, the d-c level at which the cameras of the transmitter picked up the original color information has been lost in the receiver.

This d-c level is re-inserted by the circuit shown in Figure 4. If it were not, the average brightness level as well as the chrominance information will be at difference levels producing varying brightness, hue, and saturation.



Basing diagram of bottom view of 6BU5 beam pentode tube used as high-voltage regulator in TV.

Pin connections are: 1—NC; 2—cathode and beam shields; 3—grid No. 2; 4—grid No. 1; 5—NC; 6—cathode and beam shields; 7—heater; 8—heater; cap—plate.

The reference level for the brightness component at the transmitter is approximately 70% of the peak carrier amplitude. This is the black level which causes zero brightness or a "black" screen. This specification is the same for monochrome receivers.

Since proper contrast of "blacks" and "whites" must be maintained over a relatively long time interval, the bias at the picture tube is controlled by a d-c component.

In the d-c restorer, the polarity of the signal voltage must be correct to drive the picture tube grid negative in order to produce a "black" screen. The pulses of the demodulated signal must be negative on the control grid. Since each amplifier stage normally reverses polarity by 180 degrees, whether an odd or even number of amplifier stages is required between the video detector and control grid is determined by the polarity of the detector signal output.

Referring to Figure 4, with no signal from the demodulators, bias is established by the cathode circuit R_9 and R_{10}. At this time the control grid is more negative than the cathode since Point B is at a lower positive voltage with respect to ground than Point A. Part of the voltage at point B is taken off the series-parallel combination of R_4, R_5 and R_6. The bias for the tube is the difference of potential of point C and point A. Capacitors C_1 and C_2 block the d-c from the previous amplifier stages.

With no signal input, the voltage at the plate of the green output amplifier is at a constant value. Capacitor C_2 charges up to this value through R_6, R_5, R_3 and R_1. Capacitor C_1, resistors R_2, R_3, part of R_5, and part of R_6 form a grid load circuit for the picture tube. Capacitor C_1 also charges up to the same voltage as C_2. So with no signal, no voltage appears across R_3 once C_1 and C_2 are charged. Point D then is at the same potential as Point C and the bias for the tube is as stated before.

When a signal is fed through the receiver, the plate voltage of the green output stage varies about the no signal plate voltage point. This voltage is applied across the grid capacitor C_1 as well as across C_2.

In negative signal transmission, the darker the televised scene the smaller the amplitude of the composite signal. A smaller voltage means less variation between the average signal level and the negative blanking pulses. Therefore the blanking pulses cause the plate of the green output amplifier to change less. The discharge of capacitor C_2 is less.

After the expiration of the blanking pulse, the plate voltage rises only a small amount. Therefore, the average bias on the grid changes very little from the no signal value and the picture tube remains near cut-off.

During the transmission of a bright scene, the composite video signal is larger in amplitude than it is during a dark scene and causes V_1 to conduct more heavily than it does during a dark scene. At the expiration of the blanking pulses, the plate voltage rises and C_2 charges through R_3. The polarity of this voltage is such that point D becomes positive in respect to point C which reduces the bias on the CRT and causes the average brightness to increase. The voltage developed across R_3 will be directly proportional to the average conduction of V_1 which will be directly proportional to the average amplitude of the composite video signal at the plate of the green output amplifier. The average amplitude of the composite video signal will, of course, be proportional to the average brightness of the scene being televised.

If the average illumination of the scene being televised reduces, the amplitude of the composite video signal reduces and results in a reduction of the changes in plate voltage of the green output tube, and less voltage across R_3.

L_1 provides high frequency compensation. Resistor R_4 limits the current through the diode V_1 during conduction. R_1 isolates the capacitance of V_1 from the plate-cathode circuit of the green output amplifier.

As described here, the d-c restorer circuit is called an AUTO-

MATIC BRIGHTNESS CONTROL circuit.

Since there are three output amplifiers there are three automatic brightness control circuits, one for each control grid—green, red, and blue. Most color TV receivers have three controls which affect the brightness.

Figure 5 shows all three d-c restorer circuits. The blue d-c restorer circuit shown in Figure 5 is connected across points E and F of Figure 4. A blue background control takes some positive voltage off the brightness control as does the green background control. The blue and green background controls function as blue and green brightness controls.

Since the blue d-c restorer circuit is identical to the green, the operation of the circuit is the same.

Although the red d-c restorer circuit in Figure 5 shows the diode plate connects directly to the arm of the brilliance control, the operation of the red d-c restorer is identical to the previous two.

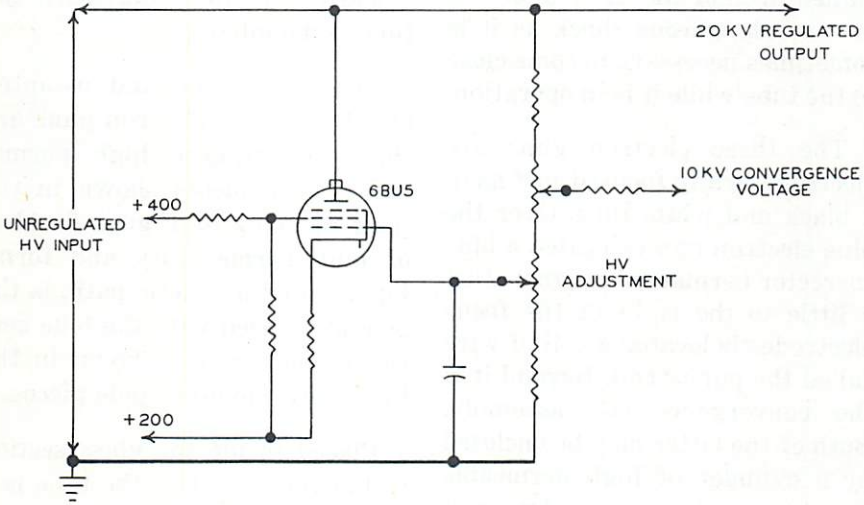
Since the red phosphor must be driven the hardest, the red d-c restorer controls the main brightness. It is adjusted before the other two since it also determines how much bias is applied to the blue and green grids. This control is more properly called the master brightness control.

Screen grid control R_7 in Figure 4 controls the accelerating voltage applied to the "green" electron beam. As shown in Figure 5, the screen of each electron gun has a separate control so that the voltage applied to each screen can be varied independently of the voltage on the other screens. Because of the different efficiencies in the light emitting capabilities of the various phosphors, the screen grid voltage and the control grid voltage of each gun must be adjusted to obtain an equal amount of light from each phosphor. Usually, the red phosphor is the most inefficient and the voltages applied to the elements of the red gun must be such that it conducts more heavily than the blue and green guns. Accordingly, in a properly adjusted receiver, the red screen voltage will be greater than the blue and green screen voltages while the bias on the red gun will be less than the bias on the blue and green guns.

COLOR PIX TUBES

Color picture (pix) tubes already in commercial production are of two general types: electrostatic (ES) convergence and electromagnetic (EM) convergence. These differences are best explained later when the specific tubes are encountered in the circuitry of a color TV receiver. In so far as the first type is concerned, the electrostatic convergence tubes are rapidly being obsoleted since they have a viewing area 12″ in diameter whereas the electromagnetic convergence tubes are being manufactured in 19″, 21″ and larger sizes.

The circuits of the receivers, other than the convergence circuits, using an ES convergence type tube, are practically identical to those having an EM convergence tube. Outer physical appearance of both tubes is alike except for the difference in size.



The 6BU5 tube is a low current, h-v beam pentode used here as a shunt regulator in a color TV receiver. About 30KV unregulated h-v is the maximum input.

Common to both types of tubes are the three electron gun assembly, purity coil, and the usual type of deflection yoke. Additional mechanical hardware mounted about the tube differs because of the type of convergence as well as the manufacturer's preferences.

EM CONVERGENCE TUBE

In the drawings of Figures 6 and 8 a number of components used with an Electromagnetic (EM) convergence tube are shown. Internal components include the electron guns, the blue corrector poles, the pole pieces for the convergence coils (labeled MAIN POLES in Figure 8), the shadow mask and the phosphor dot screen. External components include the blue corrector magnet, the purity coil, the mu-metal shield which fits around the bell of the picture tube, and the rim coil which is placed around the front of the tube between the ultor anode and the glass face plate. The ultor anode is a metal ring encircling the tube which is built as a permanent integral part of the picture tube and is used as the high voltage connector. Rubber or plastic insulating shields are carefully installed around the ultor anode to prevent dangerous shock as it is sometimes necessary to come close to the tube while it is in operation.

The three electron guns are electrostatically focused just as in a black and white tube. Over the blue electron gun is located a blue corrector permanent magnet. Just a little to the right of the focus electrodes is located a coil of wire called the purity coil. Beyond it is the convergence coil assembly. Both of the latter may be enclosed by a cylinder of high permeable metal to ward off external magnet fields, since both the purity coil and convergence magnets affect the beams through their own magnetic fields. Mounted up against the flare of the neck are the deflection yoke and its magnetic shield assembly.

Just like a black and white tube, the aquadag coating extends almost to the neck. To keep high voltage from spraying all over, an insulating coating covers the aquadag part of the way. Actually, the picture tube envelope comes in two physical separate glass pieces. They are joined at the high voltage terminal which is their junction and is a metal ring referred to as the ultor anode. This is connected to approximately 25kv of the regulated high voltage power source developed in the usual manner with a flyback transformer. A high dielectric plastic shield covers this ring when the tube is mounted.

Inside the tube and mounted about the three electron guns are three convergence high permeability pole pieces shown in the inset drawing of Figure 6. Also, of high permeability and forming a closed magnetic path, is the pole piece used with the blue corrector pole section shown in the inset with the other pole pieces.

Placed inside the glass section at the very front of the tube is a shadow mask which consists of a piece of iron alloy with holes in it. These holes allow the phosphor dot screen, printed like ink on the inner face of the tube, to be activated in the proper manner. As explained in an earlier lesson both the shadow mask and face glass are curved the same way.

All these component functions are now to be described one at a time.

Base Connections

Base pin connections for both the 19″ and 21″ EM convergence tubes are shown in Figure 7 which is the 14 pin base arrangement adopted by TV manufacturers. Notice that the metal flange or ultor is grid number 4 and 5, not pins 4 and 5. A single heater circuit through pins 1 and 14 serves all three cathodes. Pin 9 is the electrode which electrostatically focuses the three beams.

Thus, each gun has its own heater (internally connected in parallel), cathode, control grid, and accelerating electrode. Common to all three beams are the focus and high voltage electrodes.

Electron Gun Assembly

Shown in Figure 8 are the three guns and mountings forming the electron gun assembly. These guns are placed 120° apart with each of the guns slightly aimed 1° toward a common center of the tube. Effectively, each gun is at the corner of an equilateral triangle; that is, they are the same distance apart from each other. In construction, each gun is very similar to the gun currently used in black and white pix tubes. The getter loop holds the "flashing" materials which eliminate harmful gases within the tube, whereas, in receiving tubes, the getter is usually contained in a small cup.

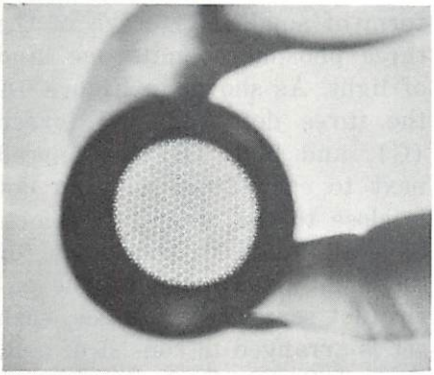
Blue corrector poles are in two sections, one mounted above and the other below grid 3 of the blue gun. Placed directly in front of grid 4 of each gun are the pole pieces of the convergence coils. Therefore, as shown in the lower inset drawing of Figure 6, the beam from each gun passes through only its own convergence magnetic field.

DOT SCREEN

In the large screen color tubes, three phosphors are applied onto the inner front glass face in the form of small dots. Each of the three phosphors emits one kind of light. As shown in Figure 9A the three dots red (R), green (G), and blue (B) are placed next to each other so each dot is close to the other two colors. Several hundred thousands of these dot trios make up the entire dot screen. As you see, each set is arranged to consist of a R, G, and B dot. Each dot in this triad of colors or dot trio occupies the same area. The center of each dot is the same distance from the other two centers within the dot trio.

Every dot trio is identical, with the centers of each forming an equilateral triangle. To keep the unused area small between dots and to prevent black spaces on the screen, the next trio is placed next to the first so that the center of any of its dots forms an equilateral triangle with the centers of the dots of the first set.

In Figure 9A, suppose we had picked three dots B_1, R_1, and G_1. If the next set of dots must have its centers form an equilateral triangle and still allow the smallest space between dots, they would of necessity be G_1, R_2, and B_3. You will notice that the only dot touching the blue and green dots is a red dot. A dot of one color never touches another dot of the same color.



Dot trio on the phosphor screen as seen through a magnifying lens.
Courtesy RCA Victor

With three beams of electrons simultaneously striking a trio of dots R_1, B_1, and G_1, the eye would see only one color since the dots are so small normal vision combines them into one.

For the entire dot screen to be of the same color and with the same fidelity as a monochrome picture, each trio of dots must be scanned at least once. Since the color transmission is compatible with the monochrome transmission, the same type of scan is used. As explained previously, the horizontal rate is approximately 15734 cps and the vertical rate 59.94 cps.

Figure 9A indicates the positions that the dots would occupy if the picture tube were constructed (looking from the front of the CRT) with the blue gun on the bottom, the red gun on the upper right and the green gun on the upper left. Actually, some tubes are manufactured with the guns and dots in different positions. For example, if the blue gun were on the top, the red gun on the lower left and the green gun on the lower right, then the dot screen would be constructed with the blue dot on the bottom, the red dot on the upper right and the green dot on the upper left. The dots must always be positioned so that the electron beams will cross over at the openings in the shadow mask and strike the correct color dots.

Now the three beams can't just scan one trio as R_1, B_1, and G_1, and then G_1, R_2 and B_3. If they did, the intensity of the three beams varying from one picture element to another at the transmitter would produce colors not in the original scene since a dot like G_1 would be scanned twice.

SHADOW MASK

A **shadow mask** prevents this error, by limiting the scan in such a way that only one trio of dots is scanned at once. The trio scanned is indicated in Figure 9A by the dotted lines. The mask is so named because between trios, the beam hits the mask instead of the screen.

The three electron beams are deflected together so that the trio consisting of B_1, R_1, G_1 is scanned; then B_4, R_4, G_4; then B_7, R_7, G_7; then B_{10}, R_{10}, G_{10}; then B_{12}, R_{12}, G_{12}; then B_{14}, R_{14}, G_{14}. On the next horizontal sweep, the in-between lines are covered so that B_3, R_3, G_3, is scanned; then B_6, R_6, G_6; then B_9, R_9, G_9; then B_{11}, R_{11}, G_{11}; then B_{13}, R_{13}, G_{13}; and finally B_{15}, R_{15}, G_{15}.

Of course, the dots are much smaller and closer together than shown and the resultant light on the picture tube screen appears solid when the viewer is standing a few feet away.

CONVERGENCE

Figure 9B shows the relative position of the three electron guns, the shadow mask, and phosphor screen.

The three beams pass through a common hole in the shadow mask. Since the centers of the dot trio form an equilateral triangle, the centers of the three guns also form an equilateral triangle as shown in the inset of Figure 9B. However, if the blue gun is at the bottom of the triangle, the beam will strike the blue dot at the screen at the top of the dot trio. The green gun at the top left of the triangle will strike the green dot at the bottom right of the triangle at the screen. The red gun at the upper right will strike the red dot at the lower left of the triangle at the screen.

Figure 9B shows the position of three electron guns at the three corners of the equilateral triangle drawn as a dashed line. The respective phosphor dots excited at the screen are shown with their centers connected by solid lines.

When the three beams meet at a common point, they are said to be in **convergence,** and the hole in the shadow mask is the proper point of convergence. If the three beams meet between the shadow mask and the electron guns, the shadow mask may cut off the beam to the screen. If the beams meet between the shadow mask and screen, the cross section of the beam at the screen forms a smaller triangle than the phosphor trio.

Consequently, assuming they are the same circular area as the dots, the three beams will overlap which results in an impure hue. In either case, whenever the beams do not coincide with the phosphor dots there is improper convergence.

D-C CONVERGENCE

In electromagnetic convergence, the three beams are positioned by a direct current for "d-c convergence". A horseshoe electromagnet, having one winding as shown in Figure 10A or having two windings connected in series, is placed over the pole pieces in the electron gun. The internal tube pole pieces complete the magnetic circuit of each electromagnet.

When a direct current is applied such that the internal pole pieces form north and south poles, the beam coming out of the paper is deflected toward the center. If the d-c is reversed, the beam will be deflected away from the center. Each magnet controls its own beam. There is practically no interaction between the three coils since the metal pole pieces inside the tube confine the magnetic field to the proper gun. When a sweep is applied, both horizontal and vertical sweep current wave-forms are impressed on the direct current through each of the convergence coils.

A later type of convergence assembly for 21″ tubes uses a permanent magnet for the d-c convergence adjustment. As shown in Figure 11A, the assembly is similar to Figure 10A and is used with the same blue beam convergence assembly of Figure 10B. Two coils are wound in series about the split horseshoe pole pieces. A square notch separates the two pole pieces where the PM fits through them. Both pole pieces are held together by a nonmagnetic clamp. Three such assemblies are mounted in the same position on the pix tube neck in the same manner shown in Figure 10A.

The magnetic field for dynamic convergence is formed in the same ways as that of Figure 10A. However, the d-c convergence is easily made independent of voltage variations by using a permanent magnet, usually, a type of ferromagnetic rod. As shown in Figure 11B, the poles are along the diameter of the rod and the magnetic field is through the diameter. The bottom half is shaded to indicate the N pole. Looking at Figure 11A, then, turning the rod to adjust for maximum or minimum field through the pole pieces certainly is a very ingenious arrangement.

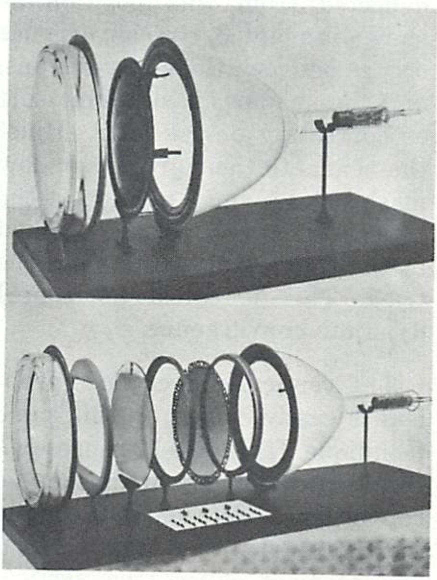
BEAM CONVERGENCE MAGNETS

Mounting three electron guns 120° apart the same distance from the center axis of the picture tube requires extreme precision. Even more *difficult is to* align shadow mask and phosphor screen with these guns. Therefore, a correcting permanent magnet similar to the beam benders used in monochrome receivers, must be used to correct these errors.

In the electromagnetic convergence tubes, a positioning magnet is used only for the blue beam. Made of high permeability material, Figure 10B shows the end view of the internal pole pieces around the blue gun. The dotted lines show the direction of the magnet field which can be formed by a permanent magnet or a d-c in an electromagnet. For better performance, the mounting bracket for the magnet is also a high permeability material and the internal pole piece prevents interaction with other beams.

Suppose the magnet has its north pole at the bottom as in Figure 10B. The lines of force are concentrated through A and spread by pole piece B. The magnetic lines pass through the glass to the outer bracket completing the magnetic path, to the south pole. With the blue beam coming out of the paper, the beam would be deflected to the left. When the polarity is reversed, the beam would be deflected to the right. Moving the magnet closer to the beam gives a greater deflection.

Thus, in an EM tube, the beams from the green and red guns can move only parallel to the walls of the inner poles. The beam from the blue gun in addition can be moved sideways by the assembly of Figure 10B. The convergence coils must be positioned physically so the horseshoe magnets are directly over the inner pole pieces. Likewise the blue beam convergence magnet must be correctly positioned. Looking at Figure 8 shows exactly where the blue **beam convergence magnet** fits, directly over grid 3 while the convergence coils and assembly fit over the main pole pieces in front of grid 4.



Two types of color TV tubes showing physical structure. Upper tube has a dot screen directly on the curved faceplate. Its shadow mask is curved also. Lower tube has dot screen on a separate flat glass plate. Its shadow mask is also flat.

Courtesy CBS, Inc.

DYNAMIC CONVERGENCE

Now, if the entire screen is to be horizontally scanned each time, the convergence must occur at each shadow mask hole. Suppose the beams were adjusted so they converged properly at the center trio of dots as shown at point A in Figure 12. When the beams are deflected from this position as shown in point B, the convergence occurs between the electron guns, and the shadow mask. Some sort of correcting device must adjust the beams to their proper shadow mask hole. A small portion of the horizontal sweep voltage applied to the convergence coils does the trick. This is called **horizontal dynamic convergence.**

The vertical convergence problem is easily solved by this same technique. If Figure 12 represents the vertical sweep with the d-c convergence set at the centermost dot trio, then any vertical displacement causes the vertical convergence point to fall between the electron guns and the screen. Hence, a vertical sweep voltage is added to the convergence coils to maintain the **vertical dynamic convergence** at the shadow mask hole.

Adding an alternating current to a direct current in this manner is called **dynamic convergence.** The term applies to either the vertical or horizontal convergence.

FOCUS

In the d-c situation, where the beam is not being deflected, again a center dot trio is chosen to focus the three beams. In this type of picture tube, the focus is electrostatically controlled by an electrode in the picture tube.

With the electron beam in focus, the smallest possible dot is produced on the screen. In Figure 13, the three beams are shown in proper convergence and also properly focused at the center of the screen. A wide beam is emitted from the electron guns and narrowed down to three points on the proper dot trio. Beyond the screen, the image would appear out of focus as shown by the extended beams.

When the beam is deflected horizontally, the focal point is no longer at the screen, but between the shadow mask and the screen. The focal point remains the same distance from the gun but swings out from the screen on the arc of a curve. The convergence may still be proper but the dot covers a bigger area of the screen. Again the beams might overlap and produce color impurity.

When the screen is rounded, some compensation is achieved. However, to completely correct this fault, some horizontal sweep output voltage is added to the d-c focus voltage. This is called **dynamic focus.**

In the same manner, when the beam is deflected vertically, the focal point is no longer at the screen. Again the screen may be curved to compensate for some of the focus. However, a vertical sweep output voltage must be added for a good vertical focus.

Hence, for a complete **dynamic focus** portions of both vertical and horizontal sweep output voltages must be added to the d-c voltages.

PURITY COIL

The **purity coil** is an air core coil of two windings connected in parallel as shown in the schematic diagram of Figure 14A. The two windings produce a magnetic field through which all three beams pass. Figure 17 shows the relative position of the purity coil, beam correcting magnets, and deflection yoke. Notice that the purity coil is near the focus electrodes in the picture tube.

The purity coils produce a magnetic field across the neck of the tube. Suppose current through the coils is in such direction to produce a north pole to the left and a south pole to the right as in Figure 14. An electron beam from the blue gun is shown coming toward the screen, and the effect at the phosphor screen is that the beam is deflected down. With the polarity of the coils the same the other two beams also will be deflected down.

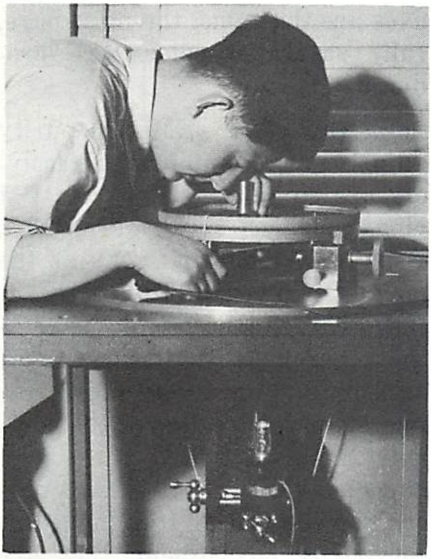
In a complete tube assembly, the purity coils may be rotated in any direction about the axis of the tube. The purity coils also may be moved along the axis of the tube. Since the current can be controlled, the axes of the three electron beams may be positioned as desired with respect to the axis of the picture tube. When these axes are the same, the most pure, fully saturated colors are produced.

Instead of an EM for purity adjustment, a number of receivers are currently using two PM rings shown in Figure 14B. Usually, a tab end is one of the magnetic poles and directly at the other end of its diameter is the other pole. In the center of each ring is an arrow representing the main direction of the magnetic field. Actually, these two rings are placed next to each other. For the initial starting point for purity adjustment, they are placed so that the magnetic fields cancel, that is, the north pole of one is placed next to the south pole of the other.

Now to move the beams in the desired direction, the tabs are rotated. As shown in Figure 14B, although the two magnetic fields are in different directions, the combined result is in the direction indicated by the third arrow. Since these purity rings are free from voltage variations, they provide a better adjustment than the EM coils.

RIM COIL

Located around the picture tube and centered between the ultor anode and the face of the picture tube is a circular coil of wire shown in Figures 15A and 15B. A direct current through the **rim coil** minimizes the effects of stray magnetic fields affecting the beam mainly due to fields passing through the metal shadow mask. The manner in which the adjustments concerning this coil are made is described in a later lesson.



Aligning the shadow mask with the phosphor screen requires precision.
Courtesy General Electric Co.

CALLED A MAGNETIC-FIELD EQUALIZER ASSEMBLY or RIM PURITY MAGNETS, eight permanent magnets sometimes are located externally to the picture tube and in the same position as the rim coil, and are used instead of the rim coil. Figure 15C shows how eight PM's are placed evenly around a metal strap. Each is held by a small mounting bracket and thumb screw. The thumb screw can bring the magnets in and out and also an inner locking nut holds it in a fixed direction.

Thus, each magnet can be adjusted individually to correct for local color impurity or fringing whereas the rim coil must undergo an overall adjustment. The magnet is placed so that its field can be turned to cancel the stray field as the beam strikes the dot screen. Since the magnet can be turned in either direction and moved closer or further, the beam can be deflected in any direction to compensate for stray magnetic interference.

ELECTROSTATIC CONVERGENCE TUBE

To date, the only shadow mask picture tubes having electrostatic convergence have small viewing screens. With the advent of the larger picture tubes, all of which are electromagnetic, the 15″ electrostatic (ES) tube has, for the time being, become obsolete.

Generally, the outer physical appearance of an ES and EM convergence picture tube is similar. Of course, the EM is much larger in diameter at the screen, but the overall length of each is still about 21″.

An outline of the ES convergence picture tube with some of its external components is shown in Figure 17. Externally located are three individual gun magnets, a purity coil, and deflection yoke. The external aquadag coating extends almost to the flare of the picture tube neck. Partially covering this coating is the external insulating coating. The ultor anode is formed in the same manner as on the large screen color TV picture tubes.

On the inside of the tube are three separate electron guns, with a convergence electrode common to all three, thus giving the tube its electrostatic convergence. The shadow mask has sets of uniform holes in it like in the larger tubes, but unlike the larger, it is a flat plate and not curved. The dot screen is not printed directly on the glass face plate, but on a separate phosphor dot plate which is also flat. Thus, in the small screen tube there is an additional mechanical set-up problem to align the mask with this separate dot screen.

Base Connections

Since the internal gun structure has an ES convergence electrode, you can expect the base connections shown in Figure 18 to be slightly different from the large screen type. There are 20 external pins, not counting the **ultor connection.** The heaters are internally connected in parallel, while each gun has its own cathode, control grid, and screen grid. Common to all three guns are the electrostatic convergence electrode pin 13 or G_4 and the focus electrode pin 6 or G_3.

Electron Gun Assembly

The view of Figure 19 shows the electron gun assembly, while the electrode voltages given in the drawing use ground as a reference. Notice that the getter assembly is in the form of a straight tube, near grid 3. The screen grid is at some fixed B+ as in monochrome receivers and performs as an accelerating electrode. In both the large and small screen tubes however, these electrodes are connected to a potentiometer in the B+ circuit, thus allowing for an equal balance among the three electron beams.

Between the two electrodes labelled grid No. 4 is formed the electrostatic field which converges the three electron beams at the proper holes in the shadow mask.

It works in the same way explained for electrostatic focusing, except that what happened to the electrons in one beam now happens to the three beams.

Furthermore, these electron guns are parallel to each other and are not tilted toward the axis of the tube as in the larger EM convergence tubes. As a result, along with the flat mask and phosphor dot plate, it is a little more difficult to obtain proper convergence at the edges than it is in the EM convergence tube.

BEAM POSITIONING MAGNETS

To position each beam individually, three separate adjustable permanent magnets are used. Mounting three electron guns 120° apart as in Figure 20A requires extreme precision. With the additional problem of aligning the shadow mask with the separate dot screen, the problem of pix tube set-up is magnified. Therefore, three beam positioning magnets must be used with this type of tube.

In Figure 20A, the beam positioning magnets are mounted directly over each gun. In Figure 20B is shown an actual set of beam positioning magnets. These are exactly 120° apart and have screw driver slots for ease in adjustment. Preferably, nonmetal screw drivers should be used to bring them in and out from the guns.

CONVERGENCE ADJUSTMENTS

In the ES convergence tubes, d-c convergence is obtained by applying a variable direct voltage to the convergence electrode. In conjunction with the beam positioning magnets, this voltage is adjusted so that convergence is obtained at the center of the picture tube screen.

When the beams are deflected away from the center, dynamic convergence is obtained by adding a portion of the horizontal and vertical sweep voltages to the direct voltage. However, these dynamic convergence voltages are shaped into parabolas before being added.

The complete procedure for adjusting the convergence circuits will be described in a later lesson along with the effect of the magnets and the convergence voltage on the electron beams.

DEFLECTION YOKE AND CENTERING CONTROLS

The deflection yoke is composed of two sets of coils, one set for the horizontal and the other for vertical deflection. As shown in Figure 21, they are located in the same position as for a monochrome picture tube. Shown also are the various component locations on the 15″ picture tube. Notice that the various components are in the same relative positions as on the larger screen picture tubes shown in Figures 16A and 16B.

As shown in Figure 22, the vertical deflection coil is in series with the vertical centering control. Current through the coils may be in either direction by adjusting the vertical centering control which comes off the B+ supply.

The horizontal deflection coils are connected in parallel with part of the horizontal output and high voltage transformer as shown in Figure 23.

In series with the horizontal deflection coils is part of the horizontal centering control. The B+ for the centering control is obtained from the damper circuit. Capacitor C_3 is for neutralization. Without it, the horizontal scan lines on the left side of the raster are displaced vertically and proper beam convergence is not obtained. Color impurity is the result.

DAMPING CIRCUIT

In picture tubes using electromagnetic deflection a damping tube is used to suppress any oscillations between 75 and 100 kilocycles occurring during the flyback time of the retrace. Figure 23 shows a common type of damper circuit with a boost voltage which consists of part of R_2, C_3, part of T_2, V_1, both primary and secondary of T_1, and the horizontal centering control.

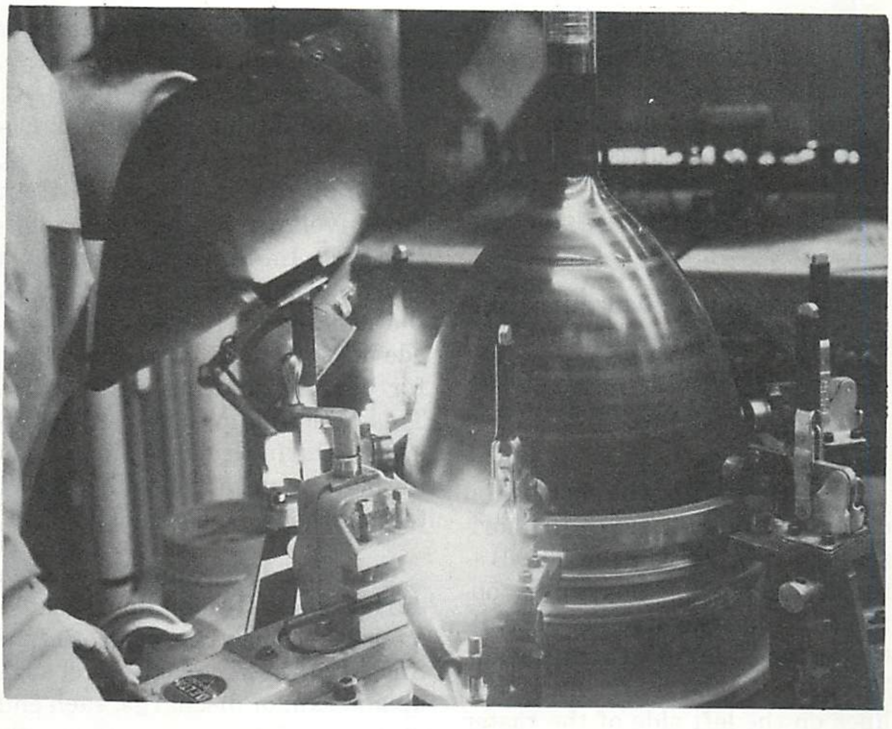
When one line of the picture is being scanned, tube V_1 conducts. Capacitors C_2, C_3, C_4, and C_6 charge up during this period. Capacitors C_1 and C_5 block the d-c and only the horizontal output sweep voltage reaches the deflection yoke L_1. Since V_1 serves as a short circuit during conduction, the winding of T_2 below the cathode of V_1 is short circuited except for current limiting resistor R_3. This action damps out any oscillation. During retrace time when its plate is negative with respect to its cathode, V_1 does not conduct.

C_4, C_2, and C_6 cannot discharge during the retrace time because V_1 is effectively an open circuit. Since the three capacitors charge up and cannot discharge, each end of the horizontal centering control is at a fixed direct voltage. The tap A is also at a fixed direct voltage. The potentiometer arm can now choose a voltage more or less positive than the tap voltage. Since each end of the horizontal deflection coil is at a fixed direct voltage, the arm of the potentiometer can be adjusted on each side of the tap so that the raster is shifted to the right or left.

FOCUS CIRCUIT

A voltage separate from the high voltage is required to simultaneously focus the three electron beams. The direct voltage needed is approximately 3 kv. A focus circuit using the horizontal output sweep from the flyback transformer is shown in Figure 24.

When the horizontal output pulses go positive, the focus rectifier conducts. Since there is no plate load, all the voltage is across the load, and the voltage across the tube is negligible. Hence, capacitor C_1 takes the full charge. C_2 provides additional filtering. Overall, C_1, C_2 and the two resistors R_1 and R_2 form a long time constant network, and therefore, the capacitors do not discharge appreciably between pulses.



Precision machined flanges on the faceplate and bulb join the two sections of this color picture tube. The faceplate is carefully welded to the bulb cone.

Courtesy General Electric Co.

This filtered voltage is adjusted by means of R_1, but once the beams are in focus usually no other adjustment is necessary. The direct voltage is applied to the focus electrode at the picture tube through the vertical convergence transformer. This applied voltage focuses the beam only at the center of the picture tube as explained earlier in the lesson. To provide focus over the entire picture tube dot screen in the large electromagnetic convergence tube, the d-c focus voltage is fed to the horizontal and vertical dynamic convergence and focus transformers. This type of focusing may be referred to as "dynamic focus".

Figure 25 shows an alternative high voltage and focus circuit. Here, the high voltage and focus rectifier tubes V_3 and V_2 respectively are at the ends of the horizontal output primary winding. In this circuit, the tubes function as half wave rectifiers. The booster voltage developed from the plus side of C_1 to ground is higher than the B+ voltage.

The horizontal output pulses ride the d-c level established by C_1. As the voltage rises to the highest instantaneous value, V_2 and V_3 conduct. Capacitor C_5 charges to the full high voltage. Resistors R_8, R_9, and R_{10} form one bleeder, and in the focus rectifier circuit R_5, R_6, R_7 form a bleeder in parallel with C_6.

If either of the voltages fall below the peak, on the next horizontal sweep pulse they are recharged to the pulse peak voltage. As indicated, the high voltage is regulated by the corona regulator tube VR_1.

When the anode has reached the operating voltage, the regulator conducts, and it draws just enough current to keep the voltage from rising above this operating value.

HIGH VOLTAGE SUPPLY

High voltage is developed from the large horizontal sweep output at the flyback transformer. Either a voltage doubler circuit or a conventional arrangement used in monochrome receivers is employed to rectify and filter the voltage. Even so, some regulation of the high voltage is desirable.

A voltage doubler and a shunt regulated high voltage supply is shown in Figure 26. Tube V_1 is the high voltage rectifier, tube V_2 is the diode coupler, and tube V_3 acts as the high voltage doubler. Capacitors C_1 and C_2 are of equal capacitance while capacitor C_3 has more than triple the C_1 capacitance.

When the high positive pulses shown are applied, V_1 conducts through C_1. V_3 conducts on the same high positive pulse as V_1 through C_3, C_2 and the bleeder consisting of R_1, R_2, R_3, R_4 and R_5. Since capacitor C_2 is less than one-third the capacitance of C_3, it charges to a greater voltage than C_3. The voltage across C_2 is less than the voltage across C_1. This makes the cathode of V_2 more negative than the plate. So, during the flat portion of the high voltage pulse, tube V_2 conducts and C_1 partially discharges through the B+ supply and the horizontal output. This conduction charges C_2 to the polarity shown.

After several cycles C_2 charges to about the same voltage as C_1. The C_2 voltage, in series with the positive pulse from the transformer, is applied to the V_3 rectifier which charges C_3 to about twice the peak amplitude of the pulse voltage. For example, if the peak of the pulse is 10,000 volts, C_1 and C_2 charge to about this value and C_3 to about 20,000 volts.

A constant load is kept on the doubling circuit by the bleeder. The bias on the shunt regulator is the difference between fixed cathode bias supplied by the B+ supply and the positive voltage at the grid developed between B− and the movable contact of R_2. This positive voltage is proportional to the high voltage and will vary slightly as the high voltage varies.

To adjust the regulator when the output voltage is much lower than 20 kv, the tap on R_2 has to be moved away from R_3. The tube is drawing too much of the current, therefore the bias on the shunt regulator is low. If the bias is increased by moving the arm away from R_3, the tube will draw less current. The parallel combination formed by the B+ supply and V_4 with the bleeder, provides a higher equivalent resistance and the output voltage at the cathode of V_3 or plate of V_4 will rise. On the other hand, when the output voltage is high the bias is decreased to get 20 kv by moving the R_2 arm toward R_3.

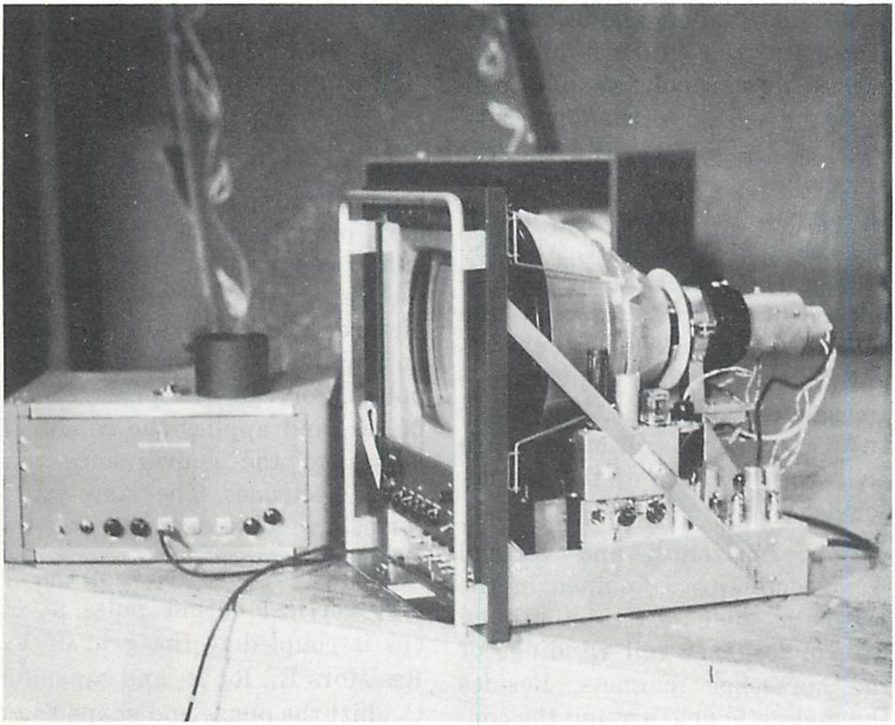
The 20 kv of the bleeder is used at the ultor terminal of the picture tube, while the voltage between the movable contact of R_4 and B− is applied to the convergence electrode at the picture tube. This direct voltage is approximately 10 kv, which is sufficient to attain d-c convergence of the three beams at the center of the shadow mask.

EM CONVERGENCE ASSEMBLY

Figure 27 is a complete circuit for horizontal and vertical dynamic convergence for the 19VP22 electromagnetic convergence tube.

In Figure 27, T_4 is a winding on the horizontal output transformer which provides the rectangular pulse as one input, while the vertical output amplifier provides a 60 cycle trapezoidal wave. Horizontal dynamic amplitude controls R_7, R_8, and R_9 are in parallel with the T_4 winding yet each control selects the retrace pulse amplitude independently of the other. C_9 and L_1 form a series resonant circuit at the 15,734 line frequency as do $C_{10}L_2$ and $C_{11}L_3$. The exact setting of these horizontal phase controls, shifts the phase of this sine wave as required.

A 60 cycle trapezoidal wave from the vertical output plate can be either positive or negative with respect to the center tap on R_1, R_2, or R_3. On one side of the tap, a negative sawtooth is applied directly to one side of inductor L_5. Capacitors C_1, C_2, C_3 merely prevent d-c through this side of the inductors. The inductor field is directed into the picture tube properly by the horseshoe magnet which also passes through the other part of the inductor.



This color television receiver is used as a monitor in a TV broadcast station control room. The side view indicates the compact assembly of the components.

Courtesy Station WCCO-TV, Minneapolis, Minn.

A close examination of the circuit of Figure 27 reveals that the sawtooth current from the vertical output stage passes through the three vertical tilt controls and through L_4 to B+. C_8 with L_4 causes a parabolic voltage to be developed at the junction of C_7, C_8, and L_4. Also the circuit shows that C_7, the convergence coil winding of L_7, the R_6C_6 combination and L_3 are in series and the entire network is across the parabolic shaping network L_4C_8. Due to the low reactance of C_7 and L_3, the vertical parabolic voltage is developed across the convergence coil and the amplitude control R_6 with the setting of R_6 determining the amplitude of the voltage across the coil. C_6 is a small capacitor to allow the horizontal convergence voltage to bypass R_6. The other two convergence coil circuits are an exact duplicate of the one described.

Both horizontal and vertical wave-forms are combined in the magnetic field existing around the convergence coil windings of the horseshoe magnets. Besides the magnetic field around the convergence coils, a magnetic field is developed by the vertical tilt coils to aid in the convergence of the beams in the vertical direction. As indicated in Figure 27, the plate current of the vertical deflection output tube is used to develop a sawtooth voltage across the vertical tilt controls R_1, R_2 and R_3. These controls then vary the amplitude and polarity of the current through the vertical tilt coils. Although not indicated in Figure 27, the static convergence adjustments are made by varying the air gap in the horseshoe shaped permanent magnets of L_5, L_6 and L_7 similar to the manner described for Figure 11A.

ELECTROSTATIC CONVERGENCE AMPLIFIERS

In the 15″ electrostatic tube, the horizontal and vertical amplifiers provide pulses for the dynamic convergence and focus to the respective electrodes at the picture tube. Figure 28A shows an amplifier which receives these pulses, corrects the phase of the pulses, and applies the combined pulses to the convergence and focus electrodes. The same waveforms are developed as for the EM convergence.

A vertical output pulse at 60 cps is coupled to the grid of V_1. Resistors R_1, R_2, R_3 and capacitor C_2 shift the phase and shape these vertical pulses so that beam focus and convergence are proper from top to bottom of the entire screen. C_2 also serves as a d-c blocking capacitor. C_1 and R_3 provide grid-leak bias and R_4 and C_3 provide cathode bias.

An iron core transformer T_2, resonant at 60 cps, provides the proper dynamic vertical convergence and focus. The secondary of the vertical transformer is tapped to provide the proper ratio of dynamic focus voltage to dynamic convergence voltage. The dynamic convergence voltages are capacitively coupled to the converging electrode and added to the d-c convergence voltage.

The horizontal output is applied across L_1, which serves as the horizontal convergence phase control.

As required, the horizontal dynamic focus and horizontal dynamic convergence transformer T_1 is resonant to the horizontal line frequency. The primary of T_1 is connected in series with the primary of T_2 while the tap on the secondary of T_1 provides the proper ratio of dynamic focus voltage to dynamic convergence voltage. The horizontal dynamic focus wave-form is applied in parallel to vertical wave-form through C_5.

The dynamic vertical and horizontal voltages across the secondaries of T_1 and T_2 are in parallel and C_4 acts as the coupling capacitor.

With correct horizontal and vertical dynamic voltages applied to both the focus and convergence electrodes, the beams remain converged at the shadow mask and focused on the screen throughout the entire raster.

Another type of horizontal and vertical convergence circuits for the small electrostatic convergence tubes is shown in Figure 28B. A pulse from the plate of the vertical output stage is coupled directly to R_1. R_1 and R_2 are voltage dividers. Whereas C_1, R_3, C_2 and R_4 function as a wave shaping network. R_4 adjusts for the correct vertical phase. The pulse is amplified and fed to one winding of the transformer T_1.

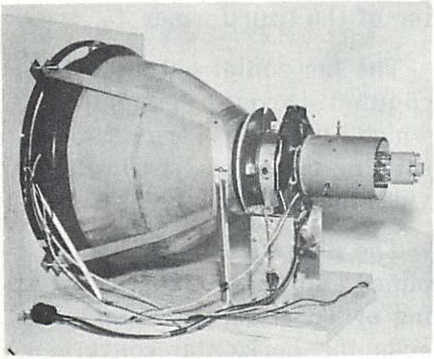
The horizontal output pulse is coupled through capacitor C_5 which, with L_1 forms a phase shifting circuit. Resistor R_6 provides the cathode bias for tube V_2.

The phase shifted pulse is amplified and fed to the other winding of T_1. Here, the transformer adds the horizontal convergence pulse to the vertical convergence pulse, and capacitor C_6 removes the d-c from the plate of V_1 from the combined pulse. Then, the combined convergence pulse is applied to the d-c convergence voltage selected at R_8.

LOW VOLTAGE SUPPLIES

The power required for a color television receiver is about double the power in a monochrome receiver. The large power is needed because there are approximately one and one-half times the number of tubes in a monochrome receiver. Otherwise, the power supply is the same as that used in a monochrome receiver. Figure 29 shows a typical low voltage power supply.

The vertical centering circuit is part of the B+ filter supply. Notice the purity coil circuit is taken off the half-wave rectifier circuit consisting of SR_1 and C_3, L_1, R_1. Resistor R_2 controls the current through the purity coils. In this case, the minimum current required that gets the desired result is the best setting of R_2. Choke L_1 helps to filter the negative half waves. At the junction of L_1 and R_2 a negative voltage (with respect to ground) of approximately 5 volts is applied to the Q and I demodulator suppressor grids. The voltages applied to the various stages are taken from the terminal marked B+.



Tri-color picture tube shows location of associated components.
Courtesy Sentinel Radio Corporation

TYPICAL TV RECEIVERS

Figure 30 shows a complete RCA color TV receiver schematic and Figure 31 is a Motorola color TV receiver diagram. These schematics are included so that you can observe the differences that occur in the various receivers and to get an idea of how the various circuits are connected together.

A careful examination of the two schematic diagrams will reveal important differences in the color circuits of the receiver. The Motorola employs R-Y and B-Y demodulators while the RCA uses R-Y and Q demodulators. The RCA mixes the demodulated color signals with the luminance signal in the adder circuits and applies the combined signal to the grids of the color picture tube; the Motorola has the luminance signal applied to parallel connected cathodes and the color-difference signals to the individual grids of the picture tube. Another point of interest is that d-c reinsertion is not used in the Motorola receiver.

TROUBLESHOOTING PROCEDURES

To locate any trouble in the color TV receiver the same technique is used as that in black and white. Isolate the trouble, first in one section, a stage of the section, and finally the component of the stage.

A composite signal can be isolated in the color TV receiver by noting the sections using the monochrome and color signal and those exclusively using the color signal.

In the color TV receiver, the monochrome and color signal channel consists of the VIDEO AND SOUND CHANNEL, LUMINANCE CHANNEL, MATRIX, PICTURE TUBE AND HORIZONTAL AND VERTICAL SWEEP AND DEFLECTION. The color signal only is used by the COLOR SYNCHRONIZATION AND CHROMINANCE CHANNELS.

Before any actual troubleshooting is performed, it is wise to check the control adjustments. Misuse of the controls does cause defective receiver action. The physical location and proper use of the controls are pointed out in the manufacturer's receiver operating instructions.

With reference to the monochrome and color signal channel, the antenna must be properly installed so that the color burst at 3.58 mc is not lost due to cancellation by reflection. A sharply tuned antenna also will discriminate against color subcarrier information.

When the color receiver is functioning, the common monochrome and color sections of the receiver can be checked by tuning in a monochrome broadcast. If there is a fault, it will be in the common circuits only.

In the common circuits, a primary color shading over the entire black and white picture indicates trouble in the matrix.

Improper convergence and focus will show up in a black and white operation of the color receiver.

When there is no fault in the common circuits, the trouble lurks in the color synchronization and chrominance channel.

When there is no color on a color channel, the first thing to check is the setting of the controls, especially the chroma and fine tuning controls. The bandpass amplifier and stages up to the demodulators should be checked.

When there is no color synchronization, the picture will show up with horizontal color bands moving vertically. However, when the 3.58 mc oscillator is greatly off frequency, the picture appears to be black and white.

When there is some color sync, the 3.58 mc oscillator, may be slightly off. Possibly a slight trouble in the reactance tube amplifier, apc or color phase discriminator causes this trouble. Also, any time the demodulated signals differ in phase by more or less than 90°, improper colors will appear on the screen.

In the chroma circuits, the usual a-c hum appears as color bands across the picture tube.

So that the technician may be better fitted to service color TV receivers, the following lesson describes test equipment designed for this purpose.

* * *

IMPORTANT DEFINITIONS

ADDER—An amplifier in which I, Q and Y signals of the proper amplitude and polarity are algebraically added together to produce a desired voltage of a particular color.

BEAM CONVERGENCE MAGNET—A permanent magnet, three altogether, mounted on shield assembly in front of the cathode used to position the electron beam from that gun for d-c convergence.

DOT SCREEN—For some tubes, a flat glass plate with dot trios of the three phosphors printed on it. Others print the dots on the picture tube face.

DOT TRIO—Three dots on dot screen adjacent to each other so that lines to their centers form an equilateral triangle. One dot emits green light, the second blue light and the third red light when bombarded.

DYNAMIC CONVERGENCE—Convergence of the electric beams during one or two directions of sweep.

DYNAMIC FOCUS—Focus of the three electron beams throughout the vertical or horizontal sweep.

HORIZONTAL DYNAMIC CONVERGENCE — Dynamic convergence throughout the horizontal sweep direction.

MU-SHIELD—A high permeability shield placed around the flare of the tri-color tube to reduce effects of stray magnetic fields on deflected beams.

PURITY COIL — An electromagnetic coil positioned between the electron guns and deflection yoke to orient the common beam axis with the axis of the tube.

RIM COIL—A circular coil of wire located around the front of the picture tube and centered between the ultor anode and the face of the CRT to reduce the effect of stray magnetic fields.

SHADOW OR APERTURE MASK—A metal mask parallel to and behind the phosphor dot screen in a tri-color picture tube having holes through which the phosphor dot trios are bombarded.

ULTOR TERMINAL—The high voltage terminal on a tri-color tube located at the junction of the bulb and face.

VERTICAL DYNAMIC CONVERGENCE — Dynamic convergence throughout the vertical sweep direction.

STUDENT NOTES

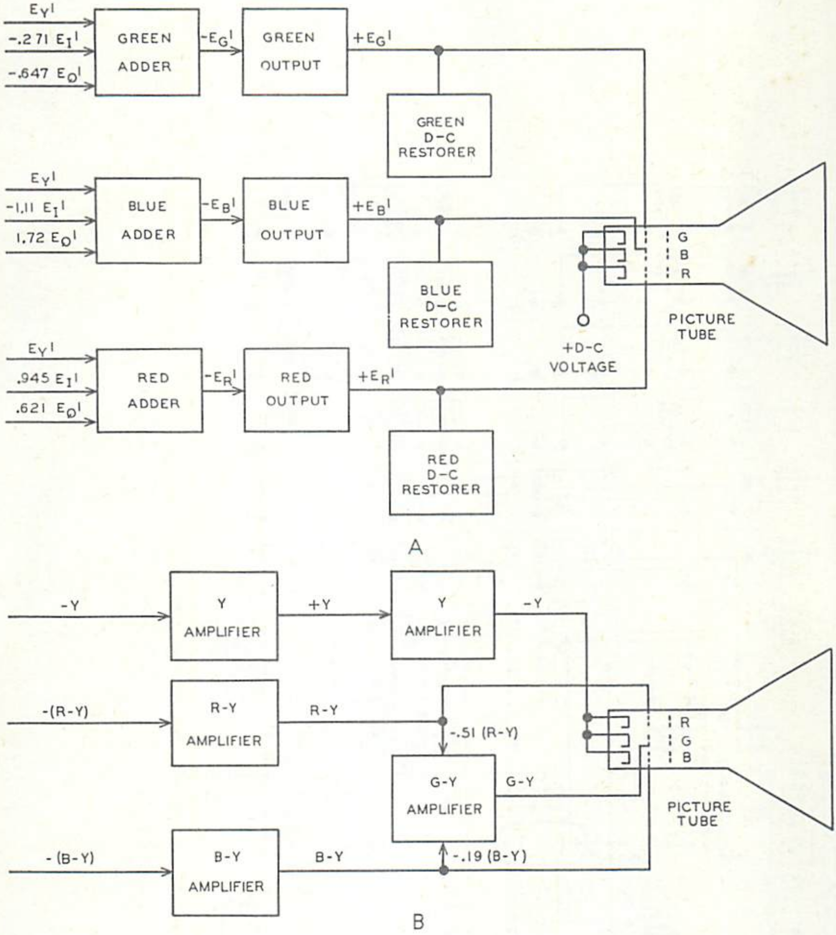


FIGURE 1

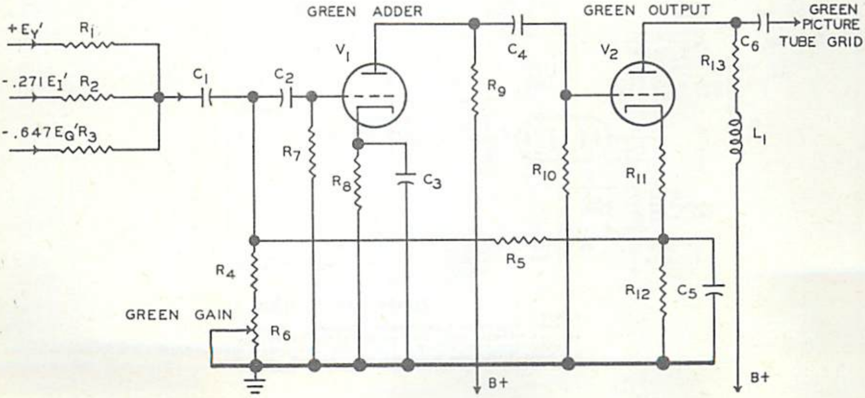


FIGURE 2

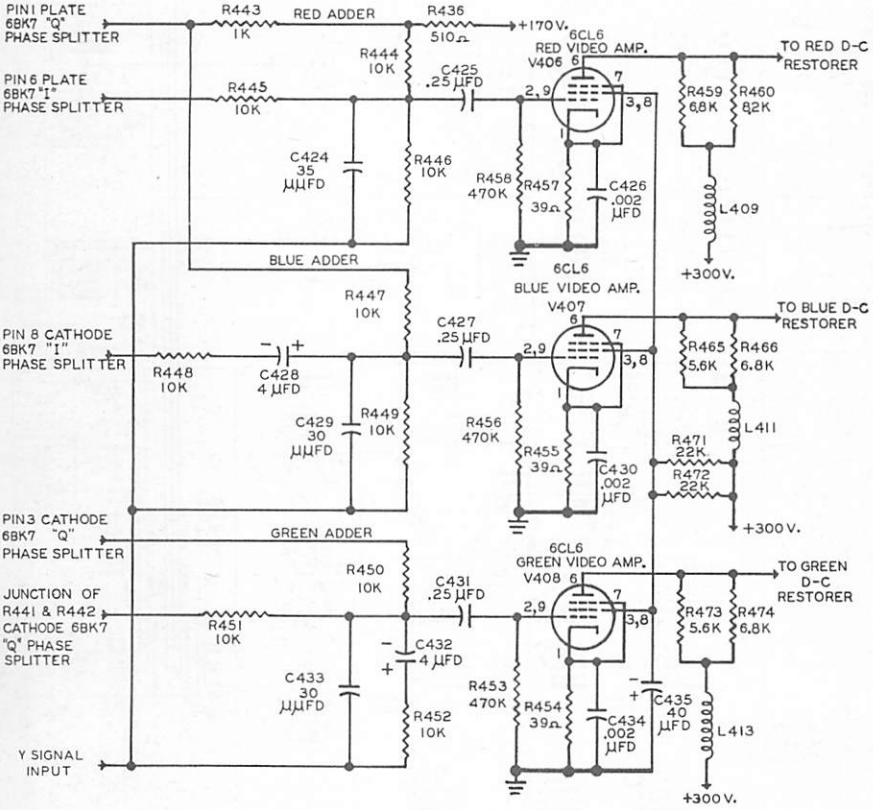

PIN 1 PLATE
6BK7 "Q"
PHASE SPLITTER
R443
1K
RED ADDER
R436
510Ω
+170 V.
6CL6
RED VIDEO AMP.
V406
TO RED D-C
RESTORER
PIN 6 PLATE
6BK7 "I"
PHASE SPLITTER
R445
10K
R444
10K
C425
.25 μFD
2, 9
6
7
3, 8
1
R459
6.8K
R460
8.2K
C424
35
μμFD
R446
10K
R458
470K
R457
39Ω
C426
.002
μFD
L409
+300 V.
BLUE ADDER
6CL6
BLUE VIDEO AMP.
V407
TO BLUE D-C
RESTORER
R447
10K
C427
.25 μFD
PIN 8 CATHODE
6BK7 "I"
PHASE SPLITTER
R448
10K
C428
4 μFD
R465
5.6K
R466
6.8K
C429
30
μμFD
R449
10K
R456
470K
R455
39Ω
L411
R471
22K
R472
22K
C430
.002
μFD
+300 V.
PIN 3 CATHODE
6BK7 "Q"
PHASE SPLITTER
GREEN ADDER
6CL6
GREEN VIDEO AMP.
V408
TO GREEN
D-C
RESTORER
R450
10K
C431
.25 μFD
JUNCTION OF
R441 & R442
CATHODE 6BK7
"Q" PHASE
SPLITTER
R451
10K
C432
4 μFD
R473
5.6K
R474
6.8K
C433
30
μμFD
R453
470K
R454
39Ω
C434
.002
μFD
C435
40
μFD
L413
R452
10K
Y SIGNAL
INPUT
+300 V.

FIGURE 3

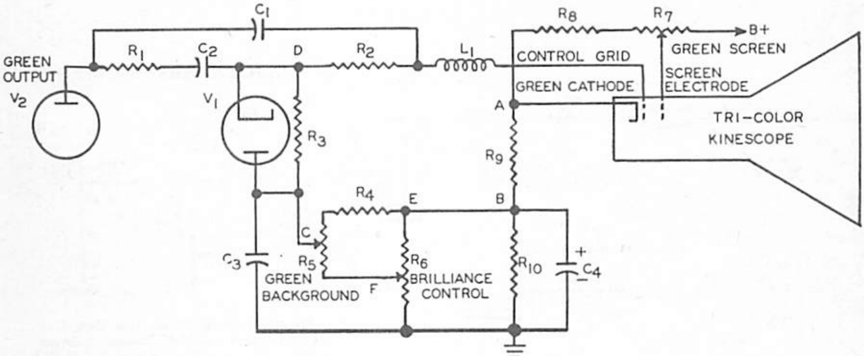


FIGURE 4

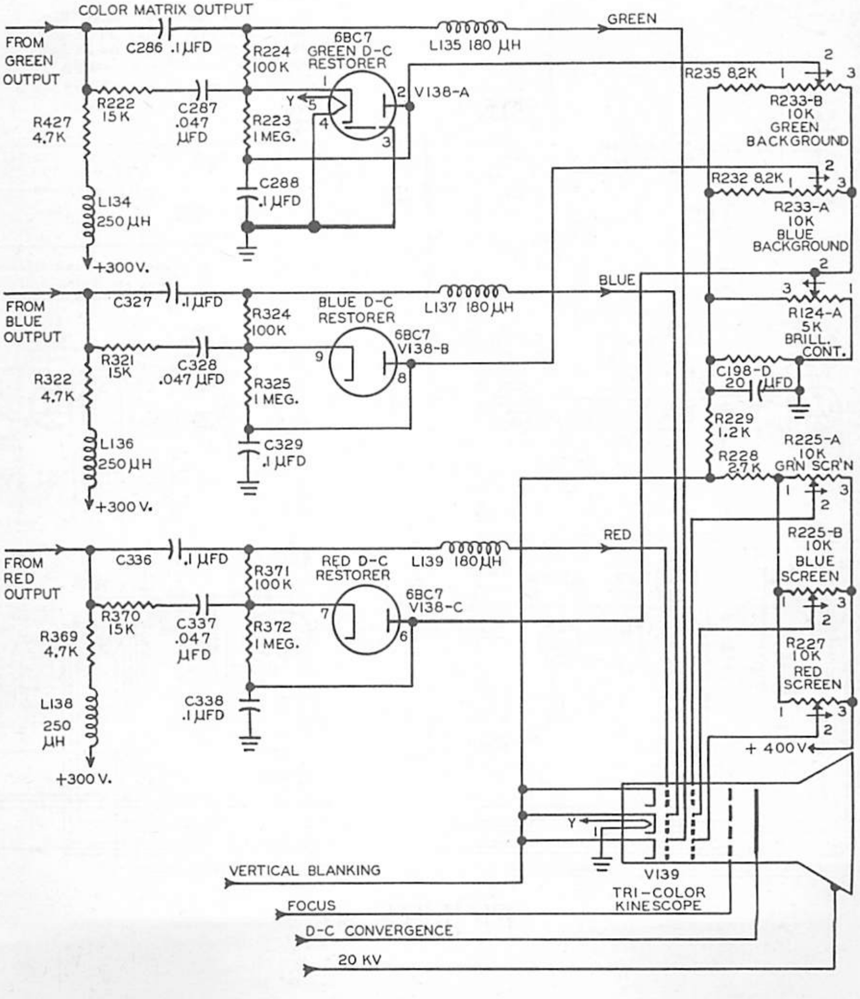


FIGURE 5

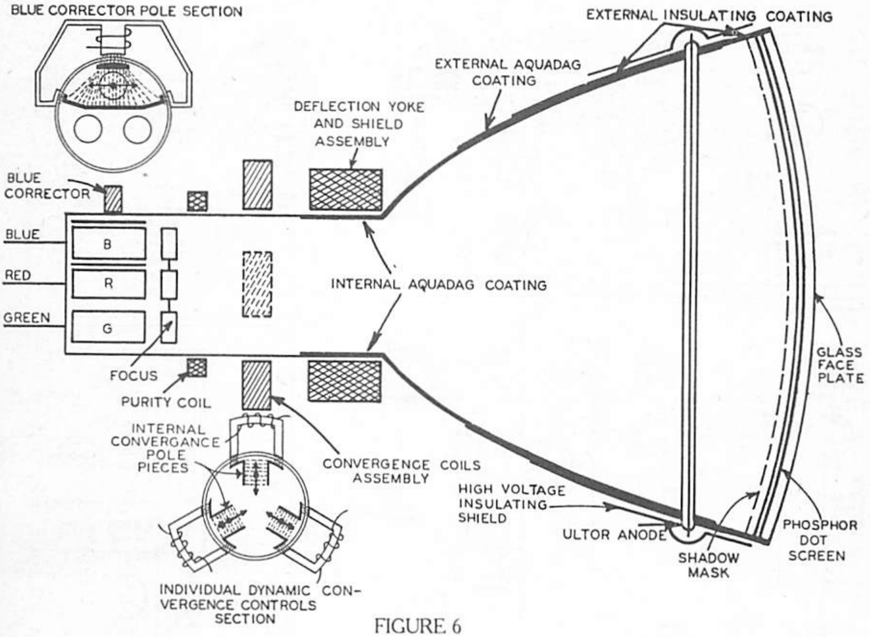
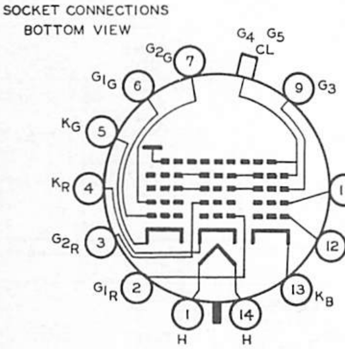

BLUE CORRECTOR POLE SECTION
EXTERNAL INSULATING COATING
EXTERNAL AQUADAG COATING
DEFLECTION YOKE AND SHIELD ASSEMBLY
BLUE CORRECTOR
BLUE
B
RED
R
GREEN
G
INTERNAL AQUADAG COATING
GLASS FACE PLATE
FOCUS
PURITY COIL
INTERNAL CONVERGANCE POLE PIECES
CONVERGENCE COILS ASSEMBLY
HIGH VOLTAGE INSULATING SHIELD
ULTOR ANODE
SHADOW MASK
PHOSPHOR DOT SCREEN
INDIVIDUAL DYNAMIC CONVERGENCE CONTROLS SECTION

FIGURE 6



PIN 1: HEATER
PIN 2: GRID NO. 1 OF RED GUN
PIN 3: GRID NO. 2 OF RED GUN
PIN 4: CATHODE OF RED GUN
PIN 5: CATHODE OF GREEN GUN
PIN 6: GRID NO. 1 OF GREEN GUN
PIN 7: GRID NO. 2 OF GREEN GUN
PIN 9: GRIDS NO. 3
PIN 11: GRID NO. 2 OF BLUE GUN
PIN 12: GRID NO. 1 OF BLUE GUN
PIN 13: CATHODE OF BLUE GUN
PIN 14: HEATER
METAL FLANGE: ULTOR (GRID NO. 4, GRID NO. 5, COLLECTOR)

FIGURE 7

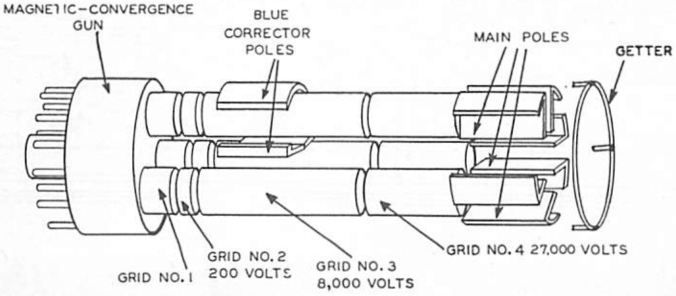


FIGURE 8

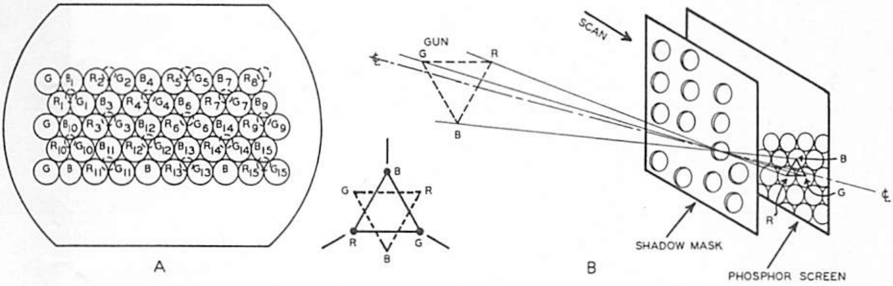


FIGURE 9

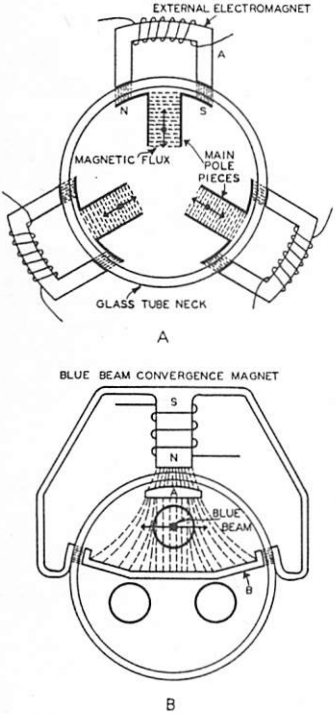


FIGURE 10

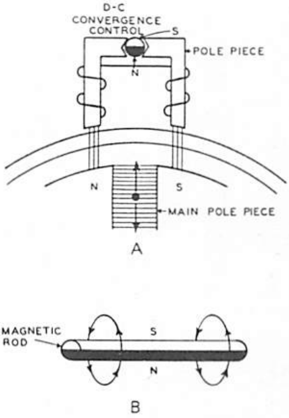


FIGURE 11

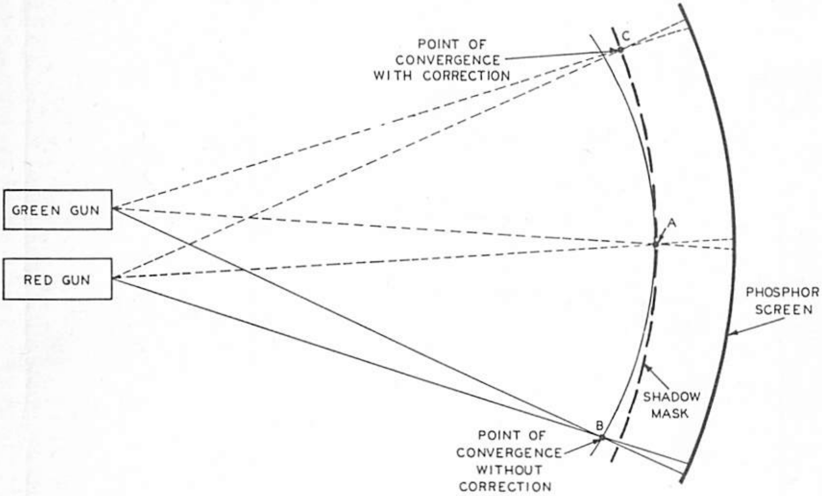


FIGURE 12

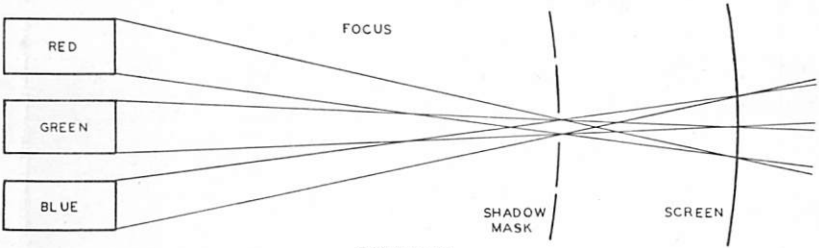


FIGURE 13

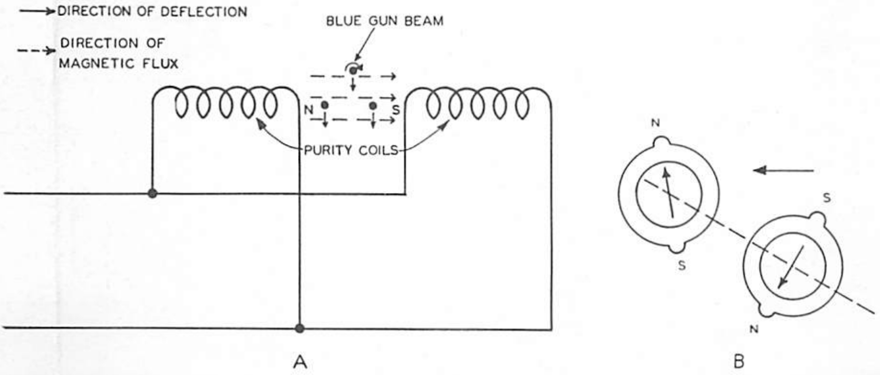


FIGURE 14

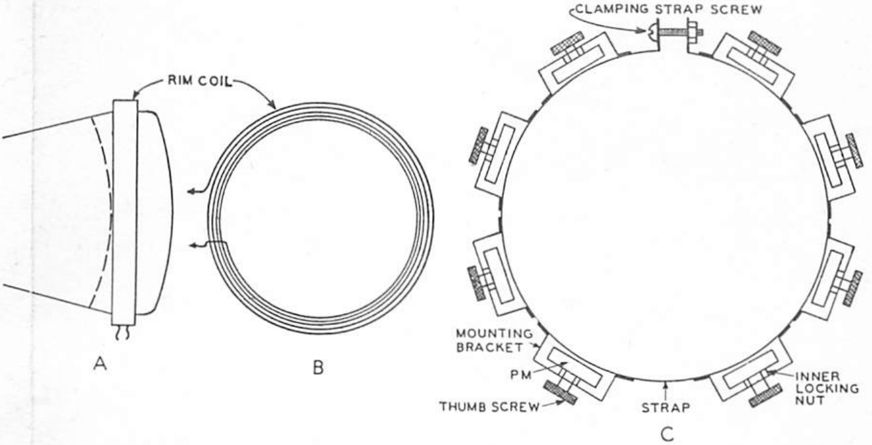


FIGURE 15

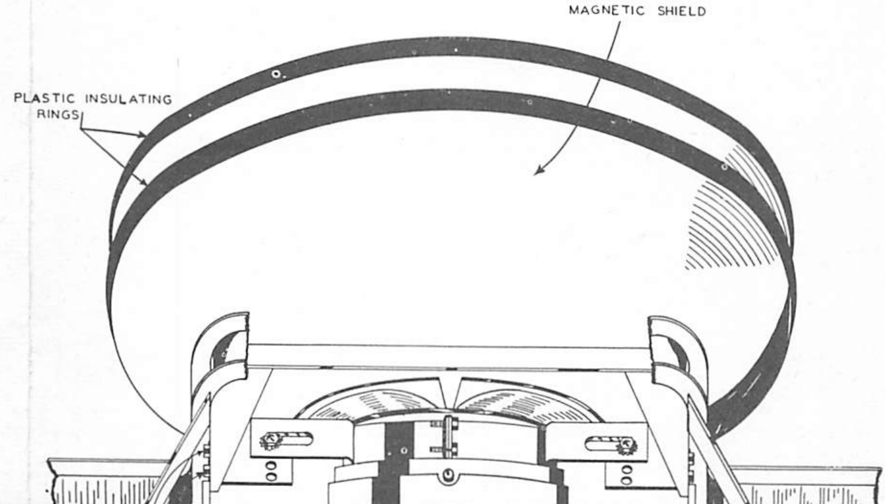
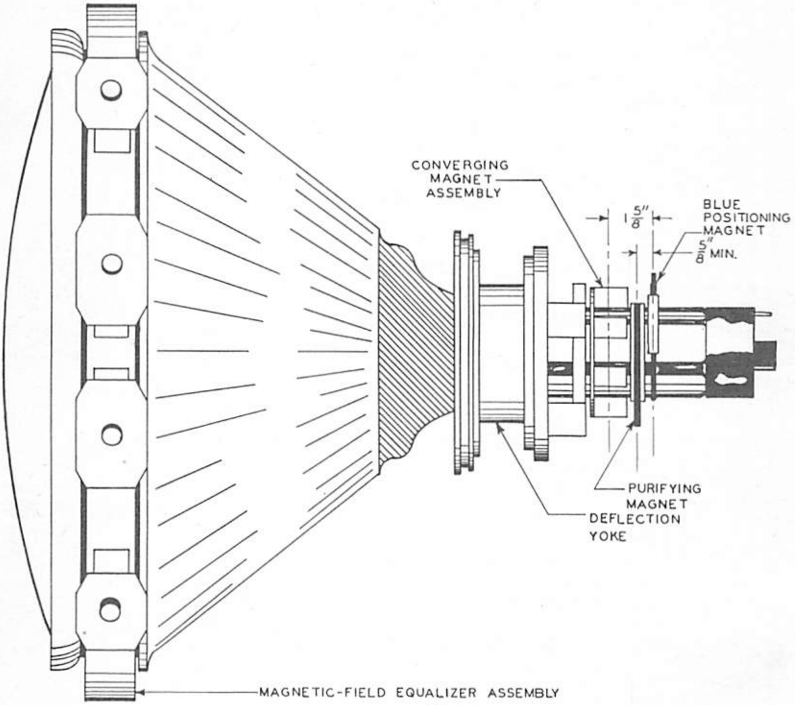

MAGNETIC SHIELD
PLASTIC INSULATING RINGS
GROUNDED YOKE BACK SHIELD
TO ADJUST YOKE FOR EDGE PURITY, LOOSEN TOP AND BOTTOM SCREWS ON EACH SIDE.
CONVERGENCE COILS MOUNTING SHIFT LEVER.
CONVERGENCE COIL
MAGNET, BEAM POSITIONING
MAGNET, BLUE LATERAL CORRECTOR
PURITY DEVICE
A

FIGURE 16



B

FIGURE 16

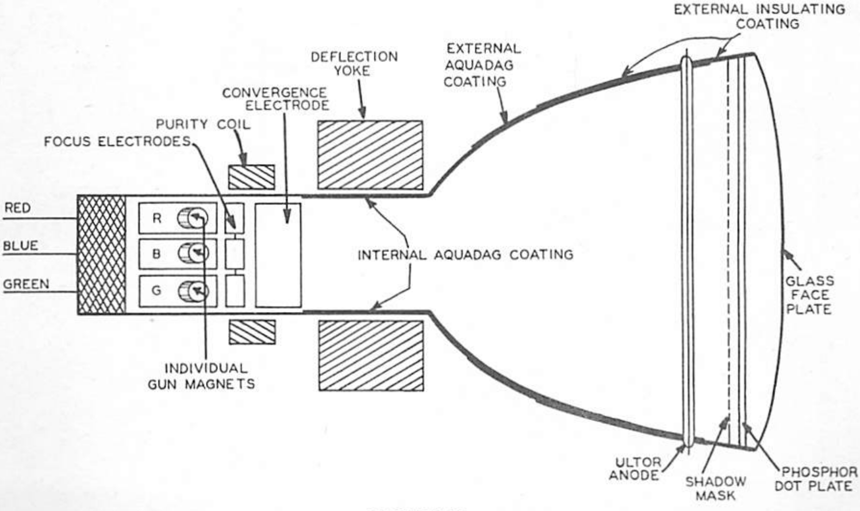
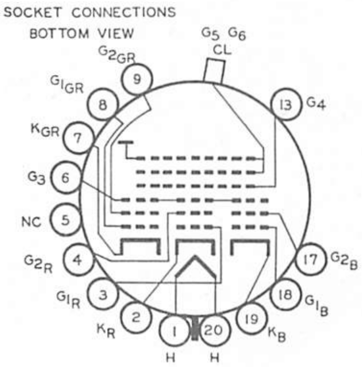


FIGURE 17



PIN 1: HEATER
PIN 2: CATHODE OF RED GUN
PIN 3: GRID NO. 1 OF RED GUN
PIN 4: GRID NO. 2 OF RED GUN
PIN 5: NO CONNECTION
PIN 6: GRID NO. 3
PIN 7: CATHODE OF GREEN GUN
PIN 8: GRID NO. 1 OF GREEN GUN
PIN 9: GRID NO. 2 OF GREEN GUN
PIN 13: GRID NO. 4
PIN 17: GRID NO. 2 OF BLUE GUN
PIN 18: GRID NO. 1 OF BLUE GUN
PIN 19: CATHODE OF BLUE GUN
PIN 20: HEATER
METAL FLANGE: ULTOR (GRID NO. 5,
GRID NO. 6, COLLECTOR)

FIGURE 18

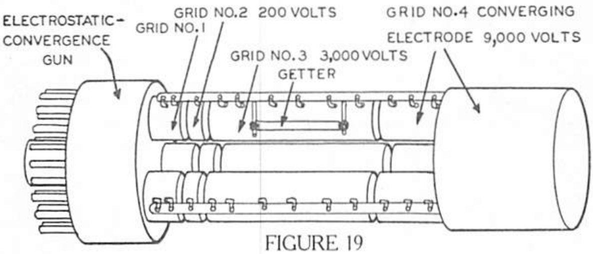


FIGURE 19

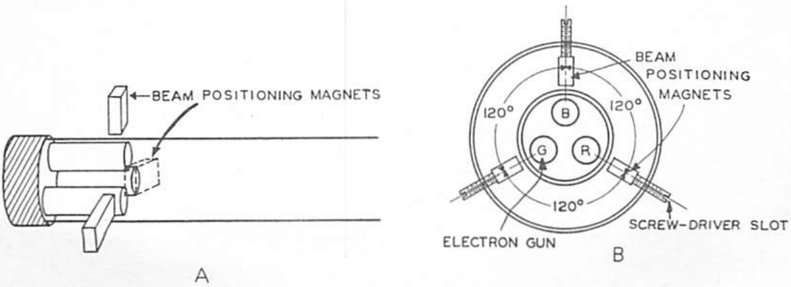


FIGURE 20

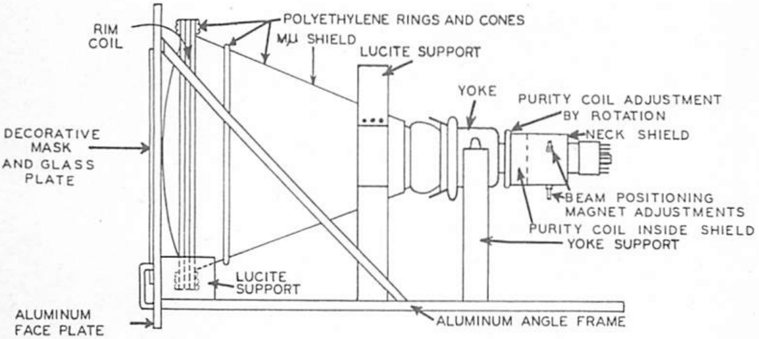

RIM COIL
POLYETHYLENE RINGS AND CONES
MU SHIELD
LUCITE SUPPORT
YOKE
PURITY COIL ADJUSTMENT BY ROTATION
NECK SHIELD
DECORATIVE MASK AND GLASS PLATE
BEAM POSITIONING MAGNET ADJUSTMENTS
PURITY COIL INSIDE SHIELD
YOKE SUPPORT
LUCITE SUPPORT
ALUMINUM FACE PLATE
ALUMINUM ANGLE FRAME

FIGURE 21

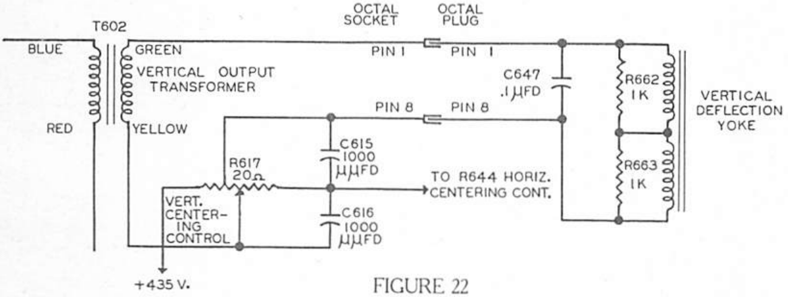


FIGURE 22

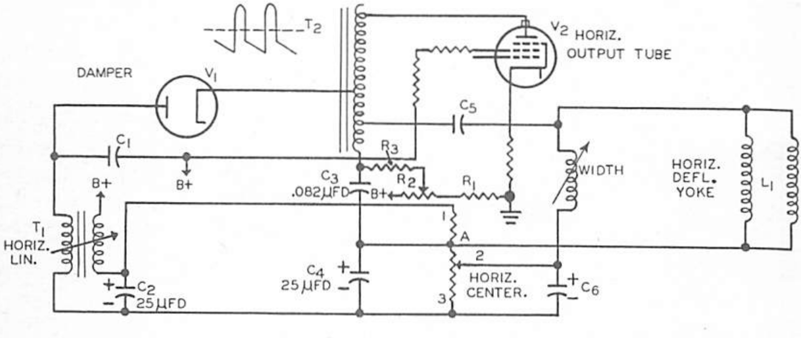


FIGURE 23

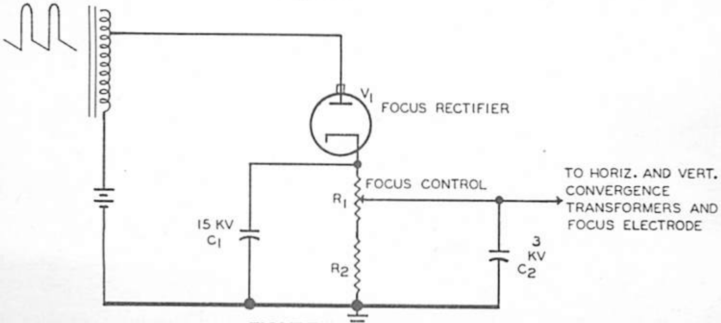

V1 FOCUS RECTIFIER
FOCUS CONTROL
R1
R2
15 KV C1
3 KV C2
TO HORIZ. AND VERT. CONVERGENCE TRANSFORMERS AND FOCUS ELECTRODE

FIGURE 24

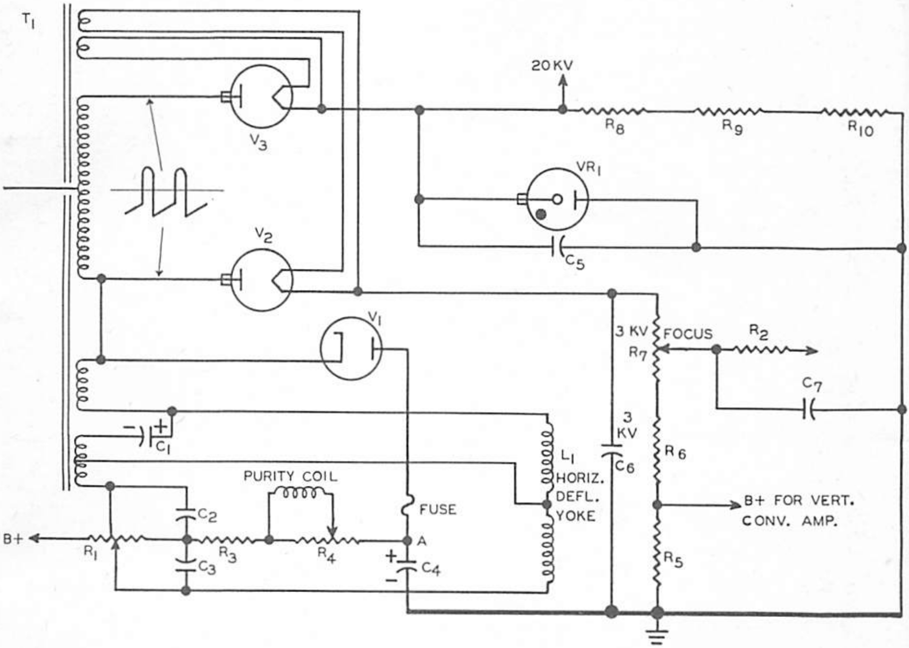


FIGURE 25

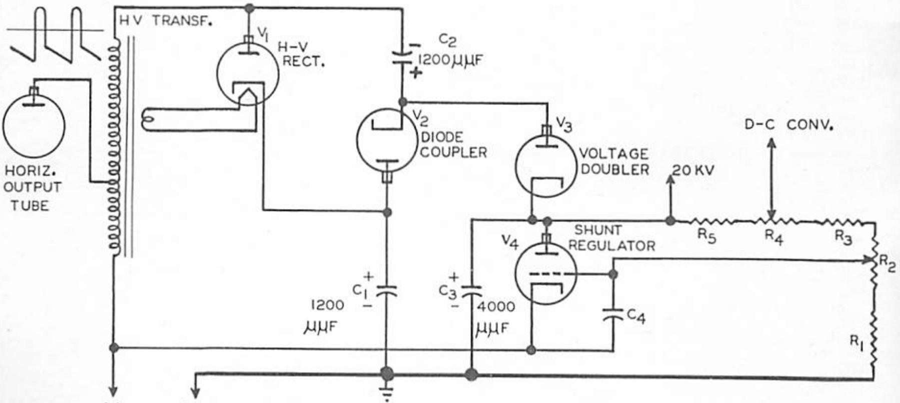


FIGURE 26

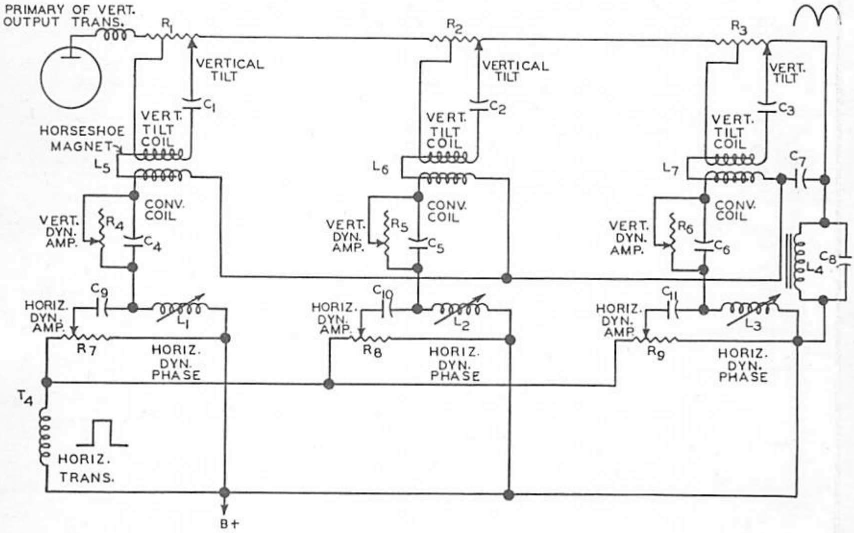
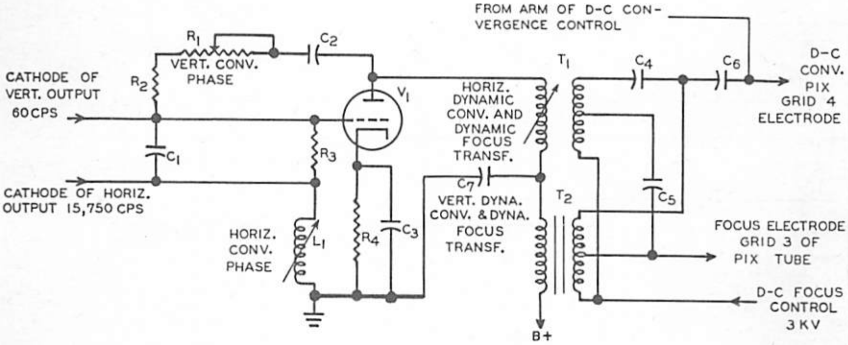


FIGURE 27


FROM ARM OF D-C CONVERGENCE CONTROL
R_1
C_2
VERT. CONV. PHASE
R_2
CATHODE OF VERT. OUTPUT 60CPS
V_1
C_1
R_3
CATHODE OF HORIZ. OUTPUT 15,750 CPS
HORIZ. CONV. PHASE
L_1
R_4
C_3
T_1
HORIZ. DYNAMIC CONV. AND DYNAMIC FOCUS TRANSF.
C_7
VERT. DYNA. CONV. & DYNA. FOCUS TRANSF.
T_2
C_4
C_6
C_5
D-C CONV. PIX GRID 4 ELECTRODE
FOCUS ELECTRODE GRID 3 OF PIX TUBE
D-C FOCUS CONTROL 3 KV
B+

A

FIGURE 28

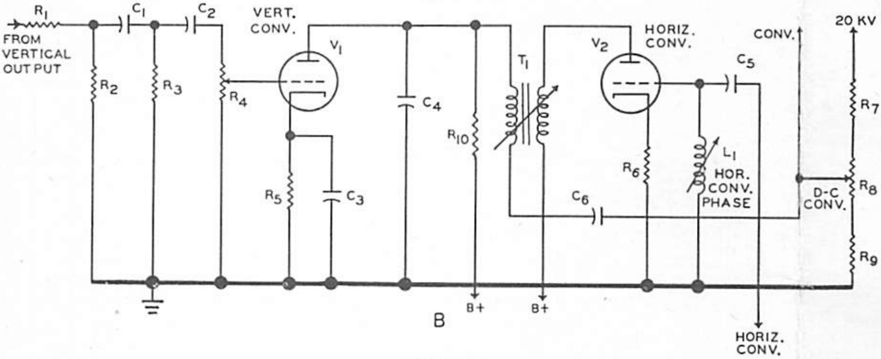


FIGURE 28

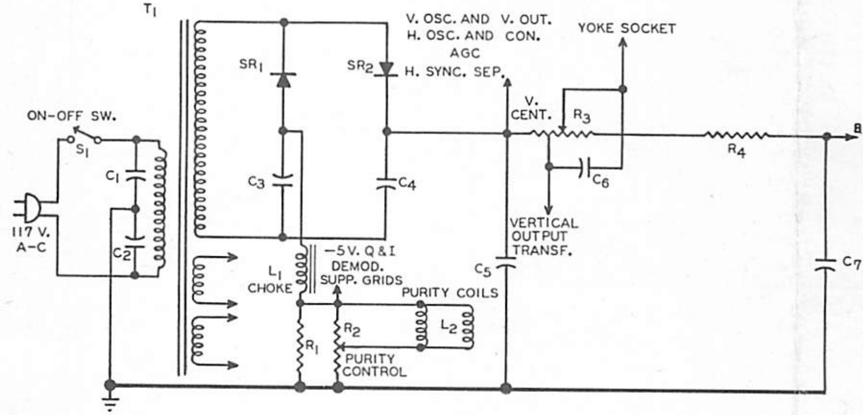
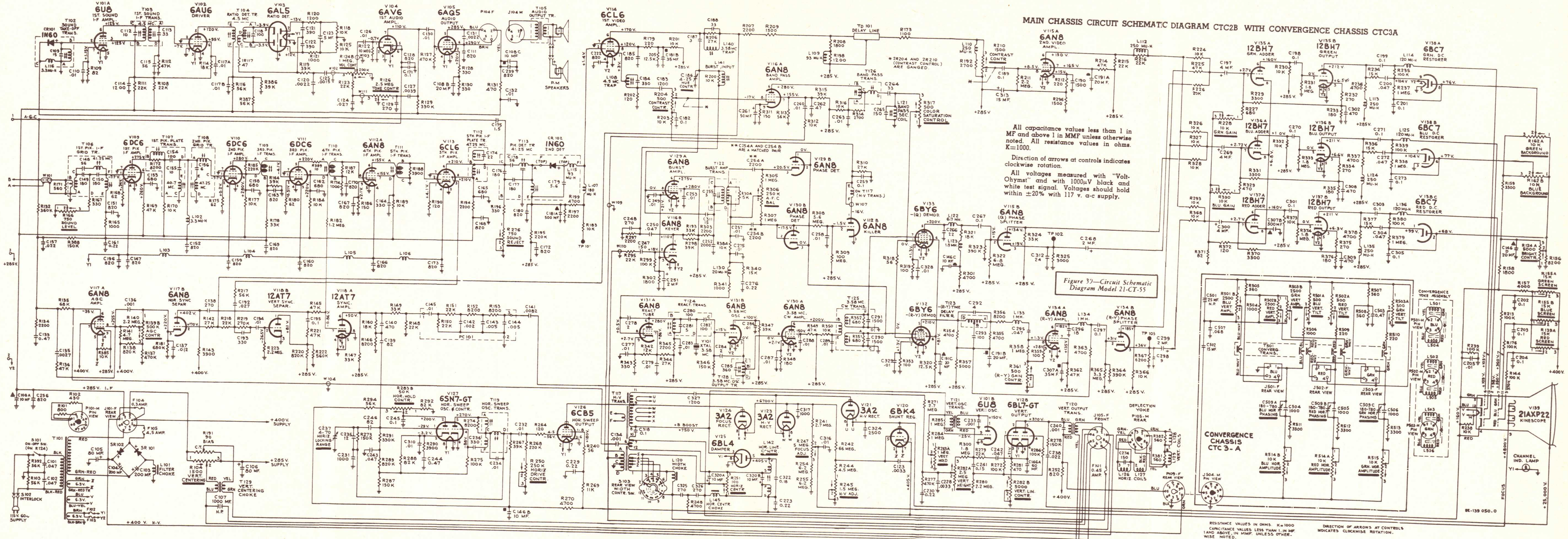


FIGURE 29

MAIN CHASSIS CIRCUIT SCHEMATIC DIAGRAM CTC2B WITH CONVERGENCE CHASSIS CTC3A



All capacitance values less than 1 in MF and above 1 in MMF unless otherwise noted. All resistance values in ohms. K=1000.

Direction of arrows at controls indicates clockwise rotation.

All voltages measured with "Volt-Ohymst" and with 1000µV black and white test signal. Voltages should hold within ±20% with 117 v. a-c supply.

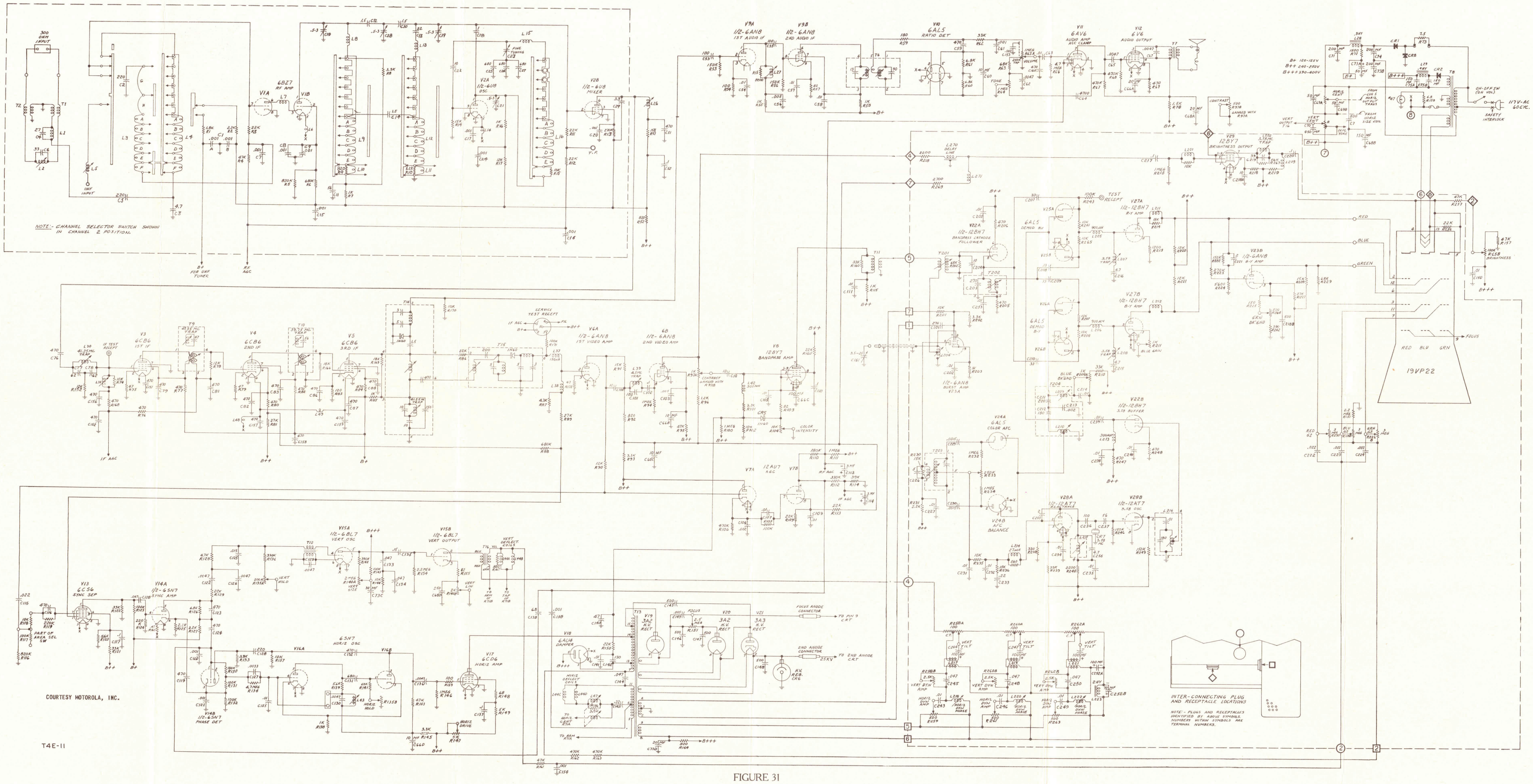
Figure 39—Circuit Schematic Diagram Model 21-CT-55

RESISTANCE VALUES IN OHMS. K=1000
CAPACITANCE VALUES LESS THAN 1, IN MF. 1 AND ABOVE, IN MMF. UNLESS OTHERWISE NOTED.
MH = MILLIHENRIES. MU-H = MICROHENRIES.

DIRECTION OF ARROWS AT CONTROLS INDICATES CLOCKWISE ROTATION.

T4E-11

FIGURE 30



COURTESY MOTOROLA, INC.

T4E-11

FIGURE 31

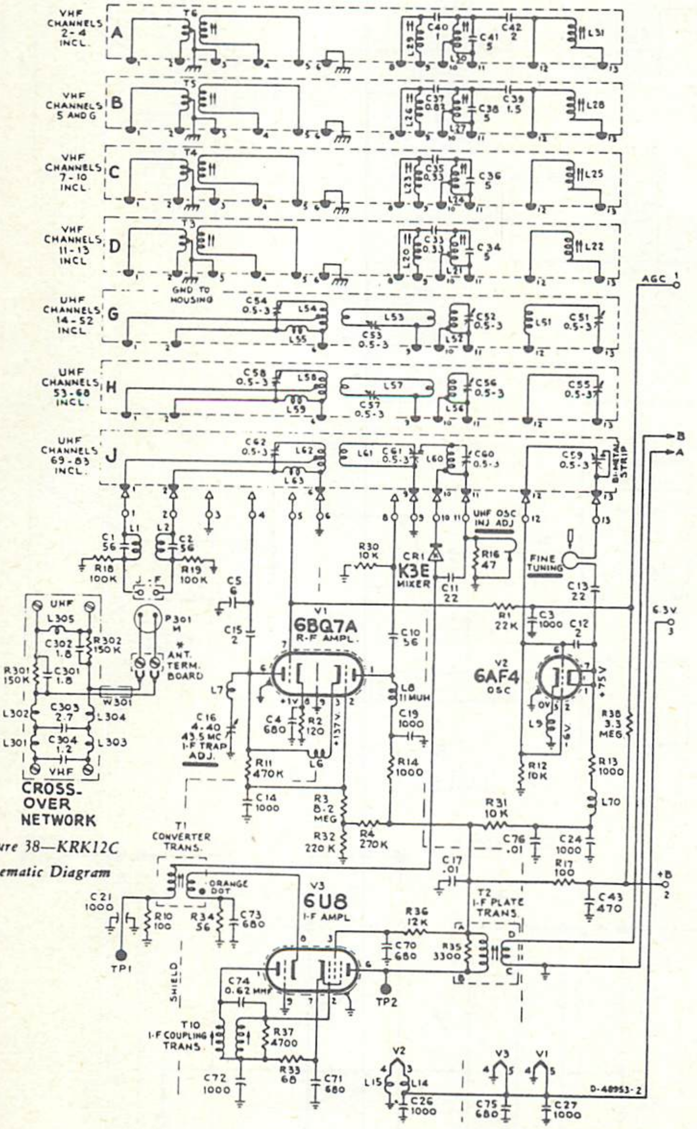


Figure 38—KRK12C Schematic Diagram

TUNER UNIT KRK-12C

* NOTE
WHEN USING CROSS-OVER NETWORK, CONNECT UHF AND VHF ANTENNA TRANSMISSION LINES TO RESPECTIVE TERMINALS.
WHEN CROSS-OVER NETWORK IS NOT USED, DISCONNECT W301 AND CONNECT UHF, VHF OR COMBINATION UHF-VHF ANTENNA TRANSMISSION LINE TO ANTENNA TERMINAL BOARD.

FROM OUR *Director's* NOTEBOOK

PROFESSION OR TRADE?

Is the TV-Radio technician a skilled tradesman or a professional man? The dictionary says he can be either one, but you'll be much better off if you put your work on a professional basis.

Here's why:

When a tradesman completes his training or apprenticeship, he needs only a blueprint or other specific details to carry out a required job. He works almost entirely with his hands, using "cut and try" methods of repair.

However, the professional man's training also provides him with the broad principles of his field, teaches him to work with his HEAD as well as his hands, and gives him the ability to find specific data when needed.

In contrast to the mechanic, the professional service technician delves into fundamentals, makes tests and measurements and solves the problem with "headwork" —in much the same way as a doctor when he diagnoses illness.

When you charge for the work you do with your hands, you compete with every hourly wage laborer on a price basis. When you charge for the work of your BRAIN there is little competition. The ceiling for earnings is fixed only by your ability, honesty, and fairness.

Yours for success,

W. C. DeVry

DIRECTOR

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T4